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## VOLUME XXXIII

July, 1945, to April, 1946

Nos 129 to 132

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BRISTOL JOHN WRIGHT & SONS LTD  
LONDON SIMPKIN MARSHALL (1941) LTD, 12 OLD BAILEY, E.C. 4  
WHOLESALE DISTRIBUTORS WM DAWSON & SONS LTD  
43 WEYMOUTH STREET, LONDON, W.1

TORONTO THE MACMILLAN CO OF CANADA LTD  
CALCUTTA BUTTERWORTH AND CO (INDIA) LTD, THACKER, SPINK AND CO BOMBAY W. THACKER AND CO  
SYDNEY ANGUS AND ROBERTSON LTD NEW ZEALAND WHITCOMBE AND TOMES LTD  
UNITED STATES OF AMERICA THE WILLIAMS AND WILKINS COMPANY, BALTIMORE, Sole Agents

PRINTED IN GREAT BRITAIN BY  
JOHN WRIGHT AND SONS LTD  
BRISTOL

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VOL XXXIII

JULY, 1945

No 129

## THE MEDICAL AND SURGICAL ASPECTS OF 'THE 'FORTY-FIVE'\* (THE JACOBITE RISING OF 1745-6)

By GORDON GORDON-TAYLOR, C B, O B E, SURGEON REAR-ADMIRAL

'THE 'Forty-Five', notwithstanding its curious nomenclature, possesses a special connotation for Scottish ears. Apart from being *Bladna Tearlach* (Charles's year) to those who speak the Gaelic tongue, 1745 was a year of no inconsiderable interest and activity in the sphere of British medicine and surgery. Fontenoy and the Jacobite Rising provided experience in military surgery, the Surgeons' Company had its inception during the late spring, and the year saw the doors thrown wide by a number of hospitals in Great Britain and Ireland. In 1745 there was opened Middlesex Hospital on the south side of Windmill Street, off Tottenham Court Road or, as the records have it, "the road from St Giles's Church to Hampstead"—with fields at its doors, "some marshy and containing ponds fed by tributaries of the Tybourne". In the self-same year, Liverpool Royal Infirmary commenced its long story of service to humanity, as did the Salop County Infirmary, the Worcester Infirmary, with a Cameron as its first physician, and the famous Rotunda in Dublin. In London, St Bartholomew's and St Thomas's on either side of the Thames dated back to previous centuries, but for 25 years before the period of '45 a succession of hospitals in the Metropolis had opened their doors—Westminster (1720), Guy's (1725), St George's (1734), and 'The London' (1741).

The 'Hospital Movement' was not confined to England. Across the Border the little hospital with 6 beds first opened in 1729 in Robertson's Close blossomed into the Edinburgh Royal Infirmary, which received patients into its wards on Dec 17, 1741. Cullen had already established a Medical School in Glasgow in 1744, illustrating his lectures by clinical cases in the wards, the Aberdeen Infirmary had been opened in 1742.

In May, 1745, the very month which witnessed the Battle of Fontenoy, the Surgeons of London, who for 205 years had been associated with the Barbers as the Barber-Surgeons' Company, were separated from the elder brotherhood by an Act of Parliament and were incorporated as an independent company, the Surgeons' Company—the theme of a previous Vicary Lecture.

On July 1, 1745, eight days before the engagement<sup>16</sup> off the Lizard between the English frigate *Lion* and the French ships *Elizabeth* and *Du Teillay*, with Prince Charles on board, the Court of Assistants of the new Company held its first meeting at the Stationers' Hall, which offered them hospitality until Surgeons' Hall in Old Bailey was ready.

Apart from the immediate medical environment of 'The 'Forty-Five', it may not be unprofitable to glance at the Britain of that period and survey the background of this tragic, if romantic, Rising. London was already a city of nearly three-quarters of a million souls, much of the Western and West-Central districts of modern London were fields, and the "New Road" which later indicated the northern limit of London proper was not yet in being (Rocque, Plan of London, 1746).<sup>16</sup> The toll-gates fortunately lacked the numbers and spared the traveller the vexations imposed by the adverse traffic-lights of to-day. Possibly the noise nuisance may have disturbed the citizen of two hundred years ago, the clattering of carts or coaches and the clop-clop of the horses' hooves upon the cobbles, intermingled with the recurrent cries of the hawker and the 'prentice boy, must have been a source of annoyance till dusk, while the nights must have resembled this war's 'black-out', and the pedestrian after twilight incurred similar risks to the modern wayfarer from slips or faulty steps between the cobbles or into the central kennel where water and refuse ran. The miserable illumination came from candles in the street windows, and the linkman fulfilled the functions nowadays performed by the more convenient electric torch.

Indoors men sat wearily in the candlelight of their drawing rooms, or in clubs considered themselves fortunate that the quota of candles per table was twice that permitted to the inns and hostleries. The city merchant still lived above his shop, and there were yet houses on London Bridge.

The south side of our own Lincoln's Inn Fields was called Portugal Row, and a hundred years were to elapse before the Hall of Lincoln's Inn raised itself to enhance the privacy of New Square and the precincts of the Law at the Eastern end of the Fields. The Duke of York's Theatre occupied the site of Room V of the Hunterian Museum before the holocaust of 1941, but at the time of the '45 the Playhouse had been commandeered by the

\* Being The Vicary Lecture of 1945, delivered within the precincts of the Royal College of Surgeons of England on Culloden Day, April 16, 1945.

military, and occupied by a detachment of the 3rd Foot Guards. Portugal Street had previously been crowded with the coaches and sedans of those who came to the theatre, but was still paced, despite the closure of the theatre, by visitors to the coffee houses in the neighbourhood, such as Willis and Serle's, and to taverns, such as "The Bell and Dragon" or "The Black Jack." The beautiful and attractive Kitty Clive had not yet come to Great Queen Street, but in this street Sir Robert Strange, the engraver, becoming involved in the '45, found shelter from his pursuers under a woman's crinoline (!)

The physicians anticipated the surgeons in their appreciation of the amenities of Lincoln's Inn Fields, for Dr Jurin was already living at No. 51 in 1745, becoming President of the Royal College of Physicians in 1750, while Sir William Watson went to practise there a few years later, remaining at No. 15 from 1757 to 1787, during part of which period he was a Censor. It was only in the last decade of the eighteenth century that the surgeons became attracted to the Square.

Malaria was an endemic pestilence in the metropolis, the marshy ground west of Tottenham Court Road and also from Chelsea down alongside the Thames was a breeding-ground for the mosquito. There had been a small-pox epidemic in 1740-42, an influenza epidemic in 1742-43, and a typhus epidemic in 1741-42 and in 1745-46.

Apart from the disabilities and drawbacks of frequently recurrent maternity, the housewife should have suffered few household worries with meat at fourpence a pound, when an experienced cook could be obtained from £15 a year, and a nurse or housemaid received £5 or £6 per annum. The footman had to be satisfied with £6 or £7 and one livery a year and had to pay for his own washing, the keep of a horse cost but sixpence a day.

Outside London, the roads of England were abominable, the turnpike stretched little more than a hundred miles northward, nor was it metalled in the middle of the eighteenth century, further towards the Border the highways were little more than tracks fit only for horses or the lumbering stage-coach, which took more than a week from London to the Scottish capital. Cumberland's hasty journey north to Edinburgh after Hawley's defeat at Falkirk, which was completed in less than 6 days, evoked special comment, but he travelled day and night. Young and old alike found it easier and quicker to travel on horseback.

In Scotland between 1725 and 1736, General Wade had industriously constructed 250 miles of roadway and built over 40 bridges, establishing a number of forts at strategic points. For the most part, however, rural districts in Scotland presented almost insurmountable difficulties to wayfarers, the country doctor counted himself fortunate if there were roads which enabled him to make his journey on horseback. Aberdeenshire, a hotbed of Jacobitism, was but little cultivated in the middle of the eighteenth century, and in some regions was little more than a wilderness of moor, bog, and stone. The Stocket Wood approached Aberdeen closely, and the road north to Old Meldrum was a mass of boulders.<sup>13</sup> The poverty of the country permitted no sons of leisure,

and the second and younger sons of the laird frequently elected the tavern or the scalpel as a means of livelihood, and even when a medical diploma had been obtained, the duress of life drove them across the seas to practise their profession—hence the Scottish 'spate' of doctors to Russia in the eighteenth century. In some cases even a combination of lancet and inn parlour was necessary to eke out a precarious livelihood in that bleak country beyond the Cheviots.

Of the literary giants of the eighteenth century Defoe, Pope, and Gay, the poet and dramatist, were already dead, Oliver Goldsmith and Edmund Burke were still at Trinity College, Dublin. In 1745 Samuel Johnson was struggling hard with poverty, sometimes roaming the streets of London without money to pay for a night's lodging, Richardson had published his *Pamela* four years before, and Fielding *Joseph Andrews* in 1742. Smollett, who had previously obtained a post as a surgeon in one of H.M. ships and visited the West Indies, had removed his name from the Navy Book in May, 1744, and settled as a surgeon in Downing Street. His *Tears of Scotland* was published in 1745, and his *Roderick Random* two years after the Rebellion was settled. Thomas Gray's "Ode on a Distant Prospect of Eton" and his "Elegy in a Country Churchyard" were both 'on the stocks' in 1745. Allan Ramsay, the Scottish poet, was almost 60 and his son, the painter, 32.

In 1745 Kneller was dead, Zoffany was only 12 years old, Gainsborough 18, and Joshua Reynolds 22, Hogarth, the Londoner, was two score years and ten, and in 1745 appeared his "Marriage à la Mode" and in 1746 the engraving of Mr Garrick in the character of Richard III. The aftermath of the Rising did not escape his attention, and in 1746 he depicted Simon Lovat at St. Albans on his way to London as a prisoner.

Adam, the architect, and Wedgwood, the potter, were still boys at the period under consideration, William Robertson, the Scottish historian, offered his services to Cope, who declined them, Adam Ferguson, the philosopher of Edinburgh, of almost the same age, was Deputy Chaplain of the Black Watch and used his claymore at Fontenoy. David Hume, philosopher, economist, and historian, was at the zenith of his course.

Newton had died in 1737, and Colin MacLaurin, the precocious Scots mathematician, died in 1746 of dropsy resulting from his exertions in organizing the defence of Edinburgh. In 1745, the Dutchman, Menschenbroek, invented the Leyden jar. James Watt (1736-1819), the engineer, was only 9 at the time of the Rebellion, and Hugh Black (1728-99) still in his 'teens, and James Hutton, the geologist, yet unborn.

Across the Irish Sea, David Garrick, then in his twenty-eighth year, played the role of Hamlet at Smock Alley, Dublin, where he also appeared as Orestes, Faulconbridge, and Iago in other Shakespearean productions. A few days after Culloden he made his first appearance as Hamlet at Covent Garden. The first performance of Handel's *Messiah* had taken place in London, in 1743.

Among the surgeons and anatomists of the period, Bartholin (d. 1738), the great Boerhaave, of

Leyden (d 1739), James Douglas (d 1742), the anatomist and man-midwife of London, and Santorini (d 1737) were already dead by the time of the Rebellion. Scarpa was scarce yet in his mother's womb when Culloden was fought, Goethe, Vicq d'Azyr, and the great Benjamin Bell, of Edinburgh (b 1749), were still in the loins of their fathers. The famous Lettsom was barely a year old, Descemet, Gimbernat, Wolfe and Wrisberg, Zinn, and William Hey, of Leeds, were little beyond boyhood. Lieberkuhn, Meckel, and von Haller were in their thirties, Heister and Morgagni were nearing their three-score years and ten, Ranby was first Master of the Surgeons' Company, and Cheselden was destined to hold this office in the year of Culloden Moor. William Hunter had reached the metropolis in 1741, but John, who was to come to London "with only immortality in his pocket", was still at Long Calderwood during Scotland's throes. Percival Pott had become assistant surgeon at St Bartholomew's in 1744, while abroad Albinus had just drawn attention to the scalenus minimus, and Bertin, from Rennes, was describing the renal columns and the sphenoidal ossicles which bear his name to-day.

Thus was the stage set for the drama of "The 'Forty-Five'".

### THE HEIGHT AND PHYSIQUE OF THE JACOBITE ARMY

The men who routed Cope's force at Prestonpans were no 'supermen', later on, when Fortune frowned, the average height of 346 prisoners of all ages, male and female, awaiting transportation in October, 1746, was found to be 5 ft 4 125 in, there was no distinct difference in physique between the West Highlanders and the men from Aberdeenshire, Angus, or East Lothian. The height compared unfavourably with that of the soldiers recruited by the Crown when London was menaced by the Highland army.

Despite the shortness of stature of many of the Highlanders, some were tall, thus, some of the Robertsons were over 6 ft\*. Age did not seem to diminish their 'toughness', Grant, of Braemar, subsequently lived to be 105 years, Threipland reached the age of 89, Pitsligo and Gordon of Glenbucket, though 67 and 72 years of age respectively, took part in the march into England and were at Culloden. Glenbucket escaped from the coast of Buchan to Norway, thence to Boulogne, where he died in 1750 in his seventy-seventh year, Pitsligo, who lived to be 84, led a hunted life in the north-east of Scotland for many years. On one occasion his asthmatic breathing nearly betrayed his presence to those in search of him.

Murdoch Mackenzie, of Letterewe, who had fought at Sheriffmuir in '15 and Glenshiel in '19, was determined to be 'out', although a very old man. His enthusiasm was damped and his activity curtailed by his wife (a daughter of MacKenzie, of Applecross) pouring hot water on his feet as if by accident and scalding him so much that he was unable to walk (!). Donald MacLeod, of Gualtergill, that Homeric figure, was nearly seventy

Donald MacLeod, of Bernera, at 53 fought in the '15 and at Prestonpans, Falkirk, and Culloden. He was 'tough' enough to disobey his Chief, MacLeod of Dunvegan, and even to fight against his own eldest son. He lived to be 90, and was called the 'Old Trojan', because of his sturdy character and numerous progeny, for his third wife was only 16 when he married her at 75, and 9 children were born of this wedlock.

On the other hand, records show that a few of the Jacobite Army had serious physical and mental defects, thus, John MacLennan, of Glengarry's Regiment, captured after Culloden, had club-feet, Andrew Porteous was "a lame object on crutches", Angus MacDougall, taken prisoner at Falkirk, is described in the Prison Returns as a "blind Highland piper", Hugh Johnston, of the Manchester Regiment was "blind of an eye".

"Keppoch's Dumbie" and David Fraser were both deaf-mutes and Matthew Matthews, of the Manchester Regiment, was deaf, nevertheless, Fraser is said to have slain seven of Hawley's men at Falkirk, the deaf-mutes doubtless had little idea of what they were fighting for.

William Hargreave had a "distempered brain", Simon Langton was almost an idiot, and in the unsuccessful defence of James Bradshaw, of Elcho's Life Guards, it was alleged that he was mad. The State Papers say of Alexander Haldane that he was "wrong in his judgement", in Aberdeen he stated that he had been dismissed from Sempill's Regiment for "lameless" \*.

### THE JACOBITE SURGEONS

Although the standard of the Jacobite Army was unfurled in the West of Scotland, and the Rising is generally believed to have been essentially an affair of the Highlands, the parts of the country from which the doctors in the Prince's Army were recruited, or where they are known to have suffered for their sympathies, were pre-eminently the North-eastern and Eastern Counties. Angus provided the greatest number, and then in descending order of contribution, Edinburgh, Perthshire, Inverness and the Isles, Fife, Aberdeenshire, etc.

There are excellent biographical notes of surgeons of the Prince's Army contained in at least two articles dealing with the medical arrangements of the '45 (a) "The Medical Heroes of The 'Forty-Five'", by W A MacNaughton<sup>20</sup>, and (b) "Story of the Army Surgeons from 1715-1748", by Major H A L Howell,<sup>21</sup> R A M C. To the exhaustive list compiled by MacNaughton I can add but few names, some of these additions were "surgeon-apprentices", others were arrested on mere suspicion of Jacobite sympathies, a fair number "carried arms" and only took up the practice of medicine after the Rising, some played the double role of leech and warrior, some were doctors and 'mine host', a few were quacks. For the convenience of any future student the following names, which are not included in MacNaughton's<sup>20</sup> comprehensive list but are available in the various literature dealing with the Rising, are appended —

\* He had deserted from the English Regiment to join Lord Drummond's Regiment and was captured at Glamis the day before Culloden.

\* Private account from descendants

Mr Maiden,<sup>8</sup> surgeon of Crail, Fifeshire, whose offence consisted only in drinking the Prince's health, William Gray and James Ratray, of Perth, and John Gordon and John Lindsay, of Montrose, are described as "surgeon-apprentices"<sup>8</sup> John Gordon, of Montrose, was probably the son of Dr William Gordon of Montrose and the great-great-grandson of Dr William Gordon, Mediciner at



FIG 1—Alexander Wood (1725-1807) (Original in the possession of Alexander W Inglis, Esq)

Kings College, Aberdeen (d 1640) He is said to have "carried arms" in England and at Falkirk and to have been "lurking" in the North (Rosebery's List, pp 168, 320)

Charles Gordon, probably of Buckie, is described as a "surgeon-apprentice", but had the rank of Captain He assisted in robbing Lord Sinclair of his horses near Portsoy<sup>1</sup> (Rosebery's List, p 28<sup>8</sup>)

Thomas Carmichael, of Perth, along with James Smyth and George Surling (the last two mentioned in MacNaughton's list), was apprehended in February, 1746, by order of James, Duke of Atholl, Lord Lieutenant of Perthshire, on suspicion of having favoured the Rising Although they do not appear to have been 'out', they were "cramped into the Tolbooth at Perth without any proper provision for their sustenance"

The two Wedderburn brothers from Dundee only embraced the profession of medicine after the Rising (Rosebery's List, p 238) The Wedderburns were Jacobites to the core, their father was captured at Culloden and hanged at Kennington—"merely because he was proved to have collected the excise for the Prince in the Counties of Angus and Kincardine" John Wedderburn (1729-1803) was only a boy of 16, but held a commission as a Lieutenant in Lord Ogilvy's Regiment, he took part in the march to Derby and back to Culloden In 1747 he went to Jamaica and practised as a surgeon

James Wedderburn (1730-1809) was also engaged in the Rising, although only 15 years of age, he also subsequently practised medicine in Jamaica

John Ogilvie (twin son of James Ogilvie, of Aucheries, Rathven, Aberdeenshire) carried arms, ultimately he became a doctor

Donald McIntyre was shown in the State Papers as a "quack doctor" He was captured at Carlisle and transported

Dr Deacon, a non-juring physician of Manchester, sent three of his sons to join the Highland Army

Alexander Wood (1725-1807),<sup>11</sup> often dubbed "Long Sandy Wood", is referred to in Lauder's "Representation" as having taken charge of 280 of Cope's wounded in the Charity Workhouse, Edinburgh, along with Lauder, "who are the surgeons belonging to that House" At the time Wood was only twenty, but subsequently this popular surgeon attained a position of great distinction in Edinburgh (Fig 1)

Dr John MacLean,<sup>11</sup> surgeon of Troternish, Skye, is mentioned as having dressed Captain Roy MacDonald's wounded foot and sent dressings to him when the Captain was hiding in caves (see p 53, loc cit)

Any account of medical aspects of the 'Forty-Five' would be woefully lacking in colour and perspective that did not include some reference to Archie Cameron (Fig 2), Threipland (Fig 3), and the Edinburgh Surgeons of the Jacobite Army like Lauder and Ratray, and also Murdoch Macdonald (see p 48, loc cit)



FIG 2—Dr Archibald Cameron (From the portrait in the National Portrait Gallery, Edinburgh)

The story of Dr Archibald Cameron (1707-53) by Lord Amulree awaits publication, and it suffices for me to make the briefest reference to some of the incidents of his life and to his death A younger brother of Lochiel, educated in Glasgow, Edinburgh, and Paris, he was a cultured physician and country gentleman, practising among his own clansmen and attending to the needs of the military road-makers working under Wade It is manifest that he was also intensely interested in the affairs of Scotland and like all his famous family an ardent Jacobite His political activities included the deputation to

Prince Charles in the *Du Teillay* before the latter set foot on the mainland, the concealment and distribution of the "Loch Arkaig treasure", and his visits to Britain subsequently to the collapse of the Rising.

Archie Cameron was also a soldier, and took an active part in the unsuccessful attack on Ruthven Barracks in September, 1745. After reaching



FIG 3—Sir Stuart Threipland (1716–1805) (Original by Delacour in the possession of Colonel W Murray-Threipland, DSO)

France in October, 1746, he was appointed to a Captaincy in the Albany Regiment, and in 1748 was made Colonel of Lord Ogilvy's Regiment in Flanders. Dr Archie was wounded at Falkirk and Culloden, he refers to the late discomforts of the wound in the chest received at Falkirk, which doubtless would have been fatal had it not been for his 'targe' "especially if the ball received at Falkirk and is still in my body give me as much pain and trouble as it did in winter and spring last which helped the continuance of my sickness at that time". He was the seventy-seventh and last of the Jacobite prisoners to be executed for complicity in the Rising on June 7, 1753.

Sir Stuart Threipland, of Fingask (1716–1805), was the chief medical adviser of the Prince till Culloden. His name, Stuart, betokens the direction of his family's loyalties. Threipland's own father had been 'out' in the '15, and the future doctor was born at Fingask when his sire was in hiding and the house occupied by Hanoverian troops. He is said to have been christened Stuart by his mother when both were expected to die, the weakling lived to be 89 (!). Threipland graduated at Edinburgh in 1742, became a Fellow of the College of Physicians of Edinburgh in 1744, and was its President from 1766 to 1770. He lost a brother at Prestonpans, went with the Highland forces to Derby and was a fugitive in the Badenoch district after Culloden along with Lochiel and Cluny MacPherson. Lochiel, who was wounded in both ankles at Culloden was his patient "until Threipland left Badenoch in July, by which time Lochiel's

wounds were so far healed that he only used to keep them clean and apply dry dressings to them" (*Lyon in Mourning*). Threipland did not render professional service to the Prince during the months which followed Culloden, since Charles Edward did not join Lochiel in Ben Alder for more than a month after the doctor had returned to Edinburgh in the guise of a Presbyterian probationer. Threipland ultimately made his escape to Rouen and found himself among a coterie of notable Jacobite exiles—Sir Robert Strange, the engraver, William Hamilton of Bangour, the poet, Andrew Lumisden, who was private secretary to both James III and Prince Charles, and William Rait, of Dundee, another surgeon. These two doctors ultimately got back their paternal acres. Threipland outlived all the great Jacobite figures of the '45, Lord Arrie having died in 1803.

Within the precincts of the Royal College of Physicians of Edinburgh is an eighteenth-century travelling medicine chest, which is traditionally called "Prince Charles's medicine chest"<sup>22</sup> and may have been brought from France to Scotland by the Prince. It was certainly in the possession of Threipland, who presented it to Alexander Wood, the surgeon ("Long Sandy Wood"), from the latter it went to his son, Dr George Wood, and then to Dr John Smith, who handed it to the Royal College of Physicians of Edinburgh. By the great courtesy of Dr T H Graham I have been privileged to inspect this chest, which measures 10 in  $\times$  10 in and presents an extraordinarily well-packed collection of phials and small pewter boxes containing salts, powders, pills, ointments, essential oils, gums, tinctures, and mixtures, etc. There is also writing material and several simple instruments.

John Congalton<sup>20</sup> belonged to an East Lothian Jacobite family and is said to have "carried arms", he was in surgical partnership with Rattray, and the firm later took in "Long Sandy Wood".

John Rattray<sup>11, 20</sup> was closely associated with George Lauder in all the surgical activities of the Rising. Reference to his share in the campaign is to be found (see pp 50, 51, loc cit). Rattray was already a Fellow of the Edinburgh College of Surgeons (1740) and one of the original members of the Honourable Company of Edinburgh Golfers, at the first match for the silver club played on Leith Links on April 2, 1744, he won the trophy. He died July 5, 1771 (*Scots Magazine*).

George Lauder,<sup>11</sup> the Edinburgh surgeon, had become a Fellow in 1737 and was President of the Edinburgh College of Surgeons in the year of the Rising. He was also in virtue of this office a member of the Town Council and witnessed some of the excited meetings which preceded the arrival of the Jacobite Army in the Scottish capital. Lauder played some part in the negotiations with the Governor of Edinburgh Castle concerning the custody of the arms which had been collected for the defence of the city, and which, falling into the grasp of the Highlanders, did no little to effect the complete rout of Cope's forces a few days later. A record of his surgical activities during the Rising are to be found elsewhere (see pp 50, 51). Lauder was one of the leading operators of Edinburgh, and was particularly successful as a lithotomist. He died



in 1762 of a fractured skull, after being thrown from his horse on his way to see a patient. Several of his pupils figured in the Rising.

George Hay<sup>11</sup> (1729-1811), of Jacobite stock, was an apprentice to George Lauder when the Prince came to Edinburgh. After four months' service with the Prince, an attack of ague compelled him to fall out, he was seized, his medical status was not



FIG 4—Sir John Pringle (1707-1782)

recognized, and his freedom not restored till the General Amnesty of 1747. Having become a Catholic, Hay could not graduate in Edinburgh or become a Licentiate of the Edinburgh College of Surgeons. He, therefore, went to Rome and prepared himself for the priesthood, his subsequent life and labours figure largely in the *Annals of the Catholic Church in Scotland*, where he attained the dignity of a Bishop.

Dr Murdoch Macleod, second (or third) son of Malcolm Macleod VIII of Raasay (wounded at Culloden, see p 12), after 1745 settled on the farm of Eyre (Skye) and began to practise medicine. He received a visit from Dr Samuel Johnson and Boswell, the former remarking that he was "glad to see him so well married, for he had a high esteem for physicians" (his wife was Anne, daughter of Alexander Macdonald of Boisdale).

### THE SURGEONS IN THE HANOVERIAN ARMY

There are very few new names among the Hanoverian doctors—a note about an unqualified doctor, Cantley, and a modicum of less known information about Brown, the garrison doctor at Inverness, and Dr Clerk, of Edinburgh.

Sir John Pringle (1707-82) (Fig 4) was senior in age to Threpland, his *vis-a-vis* on the Jacobite side, and had already a career of some distinction behind him. His duties as Physician-General to Cumberland in this campaign were almost entirely concerned with the prevention and treatment of medical conditions, and only after Culloden was he

charged with the care of wounded. In his own words, "from the middle of February, 1746, when the (Hanoverian) army crossed the Forth to the end of the campaign there had been in hospital upwards of 2000 men, including the wounded. Of this number nearly 300 died, mostly of 'malignant fever'" (i.e., typhus)<sup>12</sup>.

Pringle, in Flanders, and Huxham, in Britain, simultaneously studied influenza, both used this name and described the disease, but Huxham's book was published two years before Pringle's. The latter was far in advance of his age in matters of military hygiene, and it was also probably his suggestion that hospitals should be regarded as immune from gunfire. There is much information about Pringle in books of medical history and in other works dealing with the eighteenth century.

Alexander Monro, sen (Fig 5) was, like the rest of his clan, a stout Hanoverian, after the battle he came out from Edinburgh and attended the wounded soldiers on the field of Prestonpans, and had many Jacobite and Hanoverian injured removed to the wards of the Edinburgh Infirmary, which had been opened nearly four years before.



FIG 5—Alexander Monro, sen

Alexander Cunningham,<sup>21</sup> Surgeon to Ligonier's Dragoons (the 13th) from Nov 30, 1745 to 1752, possibly present at Prestonpans as surgeon's mate (loc cit, pp 50, 51), and William Trotter,<sup>21</sup> Surgeon to Hamilton's Dragoons (the 14th), March 21, 1745, till August, 1747, true to the highest traditions of British Army surgeons, surrendered to the Highlanders that they might attend their own wounded.

Other surgeons on the Hanoverian side were —

Hugh Hunter (*Johnston's Roll of the A M S* 293), who was Surgeon to the Highland Earl of Loudoun's Regiment, June 8, 1745, and taken prisoner at Prestonpans.

William Park (or Parck) (*Johnston's Roll*, 232), Surgeon to the garrison of Edinburgh from Feb 4, 1742, till 1754. He is referred to in documents in the Signet Library, Edinburgh, as Mr Park, Surgeon in Castle of Edinburgh, to whom several payments

for medical care of rebel prisoners are recorded (see Rosebery's *List*, p. 393)

*Patrick Blair* (*Johnston's Roll*, 157) was Surgeon to Cope's 5th Foot, July 26, 1735, to November, 1747, there is, however, no authentic record of his service in Scotland. *Joshua Pilot* (*Johnston's Roll*, 240), Surgeon to Bataillon's Regiment of Foot, a French Huguenot, is known from private papers to have been with his regiment in Scotland under Cumberland. *Francis Drummond*, Surgeon to Lascelles' Regiment, is mentioned by Lauder as sometimes coming to the Workhouse to inquire after the wounded of his regiment. *Dr James Grainger* (*Johnston's Roll*, 304), born in Duns in 1721, was apprenticed to George Lauder, the Edinburgh surgeon, and attended medical classes at the University. He joined the Army and was Surgeon to Pulteney's Regiment of Foot, being present at Falkirk and Culloden, and afterwards in Holland from 1746 to 1748, Grainger occupied his spare time with the study of Latin poets.

Doubtless the uncertainty of a livelihood in a country as bleak and poor as the Scotland of that period rendered an army surgeoncy a prize. Some correspondence reproduced in *More Culloden Papers*<sup>11</sup> refers to the candidature of a certain *Dr R Brown* as Surgeon to the troops in Inverness and other Highland garrisons. The approach to Sir John Cope for his recommendation was made through Brown's brother-in-law, Bailie William Mackintosh (sometime Burgh Treasurer of Inverness) who approached the Lord President Cope, writing from London on Nov 3 to Duncan Forbes, promised his support, but said that he must first get the approval of Wade who was at that time in Flanders.

In a subsequent letter, Nov 30, 1744, he mentions Wade's approval, and later that the King had consented to Brown succeeding Dr Cuthbert. Mention is made of considerable competition for the appointment.

MY LORD,

I had an obliging letter from Marshal Wade from Ostent in answer to mine on the subject of the surgeon, he is very glad to give his consent to your Lordship's recommendation. Sir Will Yonge not being come from Bath, I thought it best to secure Mr Pelham against other solicitations (and many there have been).

Later

The King has consented that Mr Brown shall succeed Dr Cuthbert, of which your Lordship will please to acquaint Mr Brown and I shall get his commission out as soon as I can.

*Dr Duncan Munro* (1687-1746), having acquired considerable wealth in the East Indies, returned to Scotland in 1726. He was nearly 60 years of age, and had no particular business in the action at Falkirk, but "attended lest his brother had need of him". The brother, Sir Robert Munro of Foulis, was attacked by several Highlanders of Lochiel's Regiment and was shot in the groin and received two fatal sword wounds over the eye and on the mouth. The doctor also was shot in the breast and "received terrible and fatal wounds from the sword".

Four students of "physic" belonging to the Edinburgh Company of Volunteers<sup>12</sup> joined the Hanoverian Forces, were captured at Falkirk and

subsequently escaped from Doune Castle by making ropes of their bedclothes. *William MacGhie* afterwards became physician to Guy's Hospital, *Home* was the author of "Douglas", *Barrow* dislocated his ankle and fractured several ribs in the descent, but with the help of Home and a 'borrowed' horse reached safety, *Robert Douglas* became a surgeon in the Royal Navy.

Cumberland, on assuming command of the Hanoverian troops, called for surgeons to accompany the army to Scotland. As has happened on many occasions before and since, surgeons of promise were not found wanting in their eagerness to render aid to the wounded, and even in the middle of the eighteenth century surgical experience was largely gained in the service of Mars. Three friends, *Cowell*, a young Quaker, *Thomas Dimsdale*, afterwards to acquire fame in other spheres, and *Joseph Warner* (1717-1801), each anxiously seeking hospital appointments, joined the colours. Warner soon received a surgical appointment at Guy's, became F.R.S. in 1754, was the first surgeon to ligature the common carotid artery in 1775, and was an examiner for the Surgeons' Company from 1771 till his death in 1801. Cowell was made surgeon to St Thomas's.

In addition to the doctors and surgeons there was unqualified assistance on the Hanoverian as well as the Prince's side. *Alexander Cantley*, butler to Thomas Grant, of Achnynny, was one of the earliest to take an interest in James Ferguson, the astronomer. Cantley was "clever at mathematics, music and languages and even something of a doctor".

*Dr James Clerk*, of Edinburgh, was apparently a popular physician with those chieftains who professed loyalty to the Crown. The following extract from a letter from the Laird of MacLeod to President Duncan Forbes contains a reference<sup>13</sup> to the doctor —

The rainy weather or some cause or other (but it's neither eating or drinking) has hurt me, and I'm a good deal more uneasy these four or five days with my limbs than I was. I want but the least hint from you to draw me nearer Clarky.

I am Intyrlie yours,

NORMAND MACLEOD

*John Macleod*, fourth of Talisker, "brought up to the medical profession", in 1745 joined one of the Independent Companies raised that year by the Laird of Macleod.

*Jervase Wright*,<sup>30</sup> surgeon to General Wade's Horse.

## PRESTONPANS

The engagement was brief and ended in a complete rout of Cope's force within a few minutes, the exact number of which varies from four to seven in the different accounts of the battle. "A few shots from cannon, a tempest of plaids, as the Highlanders tossed them down and ran on half-naked in their smocks, a scattered fire from their ranks, one weak volley from the English infantry, no clash of steel, but a wild yell from the Celts and then a pursuit and slaughter" (Andrew Lang).

By 1745 Sir John Cope may not have been a man in the full vigour of health. Correspondence between John Forbes and the Lord President<sup>14</sup> in

1744 refers to Cope's sojourn at Bath for the waters, to his attack of "St Anthony's Fire" there, and to his reputation as a gallant. The famous Dr William Oliver, father-in-law of Pringle, physician to Bath Mineral Waters Hospital, and inventor of the "Bath Oliver", inscribed to him some verses, being his "Advice to Sir John Cope upon his catching St Anthony's Fire by drinking Bath Waters" (Hist MMS Com Rep IX App 132, B)

See gentle Cope with love and gout oppress'd  
 Alternate torments rattling in his breast,  
 Trys at a cure, but tampers still in vain,  
 What eases one, augments the other pain  
 The charming girl who strives to lend relief,  
 Instead of healing, heightens all his grief  
 He drinks for health, but then for love he sighs,  
 Health's in her hand, destruction in her eyes,  
 She gives us water, but with each touch alas!  
 The wicked girl electrifies the glass,  
 To ease the gout we swallow draughts of love,  
 And then, like Etna, burst in fires above,  
 Sip, not, dear Knight, the daughter's liquid fire,  
 But take the healing beverage from the sire,  
 'Twill ease your gout, for love no cure is known,  
 The god of physick could not heal his own

There is another letter from Cope<sup>11</sup> to the Lord President written from Charges Street, W, in November, 1744, in which he refers to an illness associated with fever, which laid him low, his temperature may have been due to malaria, to which the suggestive word "intermitted" employed, lends some support

It is with difficulty I am able to write so much, being so weekned by a violent fever which has kept me in bed almost these fourteen days, at last it intermitted, and last night I miss'd my fitt, so all danger is over, and I must wait with patience for strength. Nothing like a Northern air for health and spirits. Heaven send your Lordship a continuance of both, for the sake of your friends in particular and the publick good

I am with great respect & truth

My Lord,

Your most obliged humble servant, JNO COPE

**The Wounded at Prestonpans**—These were, of course, predominantly Cope's men, and the numbers taken care of and the nature of the injuries can be gauged from a perusal of Lauder's "Representation"<sup>11</sup> of his case for release. I have no evidence whether he and Rattray voluntarily joined Prince Charles' service or whether they were "pressed" *vi et armis*, but both performed valuable work after Prestonpans, especially in the Edinburgh Charity Workhouse. It is difficult to find agreement with the statement "there was not a surgeon but us to be found". Munro certainly came to the battlefield and secured the removal of Hanoverian and Jacobite wounded to the Royal Infirmary, Cunningham and Trotter operated on 23 of Cope's officers in Cheapes house, but the numbers which Lauder alleges to have been dealt with by Rattray, Wood, and himself must have represented a considerable percentage of the injured (1000 of Cope's men were prisoners)

The following is headed —

REPRESENTATION OF GEORGE LAUDER, SURGEON,  
 IN EDINBURGH

The Day before the Battle of Preston Pans I was taken Prisoner from Edinburgh by the Rebels to take

care of the Wounded in case of Action, and have been detained by them for the same purpose ever since

The Officers (i.e., Hanoverian) who were made prisoners at that Battle have often told me, they reckoned it a great happiness to the Army, that I and Mr Rattray (who was in the same Situation with me) were there as a great Many of the Wounded both Officers and Soldiers must have inevitably perished, without immediate assistance, and there was not a Surgeon but us to be found

Amongst the many taken care of by me the following gentlemen were not only dressed in the field but taken care of during the whole course of their cures, viz —

Capt Poyntz who had one very dangerous wound in his hand and five in his head

Major Griffith had a large wound in his head

Lieutenant Disney had his hand cutt off with a Sword and a shot in his shoulder, and must have dyed with loss of Blood in a very short time without assistance

Lieutenant Hewitson had two dangerous wounds in his Head, one thro' both Tables of his Skull and a very bad one in his Arm

Lieutenant Swinie had a large wound on his Face

Mr Bishop son to Captain Bishop who was killed in the Action had fourteen wounds, some of them exceedingly dangerous, and must have died without extraordinary Care. I not only dressed him and operated on him, furnishing both external and internal medicines, as I did to the others, but even found him Lodgings, Nurses and Money for his Subsistance, he being an Orphan destitute of Friends and Money. Besides the above named I gave advice and the first dressings and operations to many more, who were afterwards taken care of by other Surgeons

Mr Rattray likewise took care of many amongst whom were Captain Sandilands who had Sixteen wounds

Mr (perhaps Birnie) who had six wounds and would have died with loss of Blood without instant help

Mr Rattray and I, that day likewise operated upon and dressed almost three hundred private Men, two hundred and eighty of which were taken into the Charity Work-house, where they were taken care of by Mr Wood and I, who are the Surgeons belonging to that House, but my charge of them was greatest as I performed the whole operations and furnished the Medicines out of my own Shop gratis. These facts can be attested by the Gentlemen themselves, and by Hugh Hunter Surgeon to my Lord Loudoun's Regiment who I desired some time to assist me with the Private Men, as also by Francis Drummond the Surgeon to Colonel Lascelle's Regiment, who came some times to the Work House to enquire of me concerning the Men of Colonel Lascelles Regiment. Myself and six Apprentices and Students continued daily six or eight hours a day with the said Dressings. Colonel Hallet will likewise attest that three Days after the Action he came to me (expressed) the sense he had of the obligation he lay under to me for the care I had taken of the Men, and told me that he understood that there was three or four of his men about seven Miles in the Country, who needed their Legs or Arms to be cut off, but as the Surgeon to their Regiment was only a Young man, he did not incline that the Thing should be done by his sole Advice, or even that he should be the operator. He therefore desired me to visit them, and to perform the operations if I judged them proper. I went and saw them, thought the operations unnecessary and brought the men to Edinburgh, where they were taken care of

Besides taking care of the wounded I likewise at my own expense, carryed out to the Prisoners at Colonel Gardiners House two Dozen of Wine, eight large loaves of bread, and a good quantity of Cheese

The Rev Carlyle, of Inveresk, describes collector Cheape's house on the field of Prestonpans, to which 23 of *Cope's wounded officers* had been removed. He offered his services to the busy Cunningham and Trotter, the former was at the moment attending a pale and apparently dying young Officer, Captain Blake by name, a piece of whose skull about 2 in square had been blown off.

The end-result of this operation is interesting. In a copy of *The Times* of 1801 the following note appeared —

#### LEFT AMONG THE DEAD

Among the numerous inquiries made after the Sovereign's (George III) health, the following card was left

Captain Blake of the Grenadiers, George Street, Westminster, in the Regiment of Colonel Murray at Preston Pans in 1745—left among the dead in the field of action with no less than 11 wounds, one so capital as to carry away 3 inches of his skull—Preserved 56 years to relate the event and enabled by Gracious protection to make his personal inquiries after his Majesty's health

But not only did the surgeons of both sides render succour to the wounded, but the Highlanders themselves rendered first aid to the many casualties left in their hands by the tempestuous flight of Cope and his fugitives. "I observed some of our privat men run to P Seton for ale and other liquors to support the wounded. And as one proof for all, to my own particular observation I saw a Highlander supporting a poor wounded soldier by the arms 'till he should ease nature and afterwards carry him on his back into a house and left him sixpence at parting. In all which we followed not only the dictates of humanity but the orders of our Prince in all" (*Lockhart Papers*, 1817, 2, 491 London)

For a time after Prestonpans the Royal Infirmary was practically a military hospital. The Jacobite wounded who remained after the Prince marched South automatically became prisoners, there were 18 Jacobite sick and wounded in the Infirmary between September, 1745, and April, 1746, 14 were casualties in action, of whom 2 underwent successful amputations.

Among the Highland wounded who passed into Government hands as prisoners may be mentioned —

Alexander Cameron, *shot through the chest and back*, admitted to the Royal Infirmary, Edinburgh, taken captive when the Highland Army marched south. He lived 13 months, ultimately dying of his wounds.

John Campbell was wounded at Prestonpans and admitted to the Edinburgh Royal Infirmary. Later he is described "wants left leg". Recovery.

#### CROSSING THE BORDER

"With a hundred pipers and a" the Border was crossed on Nov 8, they raised a loud shout and unsheathed their claymores. Lochiel, while in the act of drawing his weapon, accidentally cut his own hand, this was considered a bad omen.

There is a reference<sup>30</sup> to a wound of the throat received by Lord Elcho at Penrith, this was sutured.

At Derby<sup>31</sup> the doctors come into the picture, for the Mayor sent out to Charles' Camp John Davinson, merchant, John Graham, apothecary, and

Doctor Douglas, a physician, to ask for terms for the town. The answer was that terms would only be granted if the Castle was surrendered, and this was done.

#### THE WOUNDED AT FALKIRK

Lauder's "Representation"<sup>31</sup> mentions that he was without instruments, bandages, dressings, and medicines soon after Falkirk when the Jacobite force hastily departed northward, that he only got them again just before Culloden, and that they were subsequently again taken from him.

After the Battle of Falkirk, I took care of Captain Fitzgerald of Colonel Munro's Regiment, who had two wounds in his head and in a bad state of health otherwise, both he and Captain Halley must certainly be sensible too, that it was by my representation of the bad consequences, it would be to their healths, if they were carried along with the other Prisoners, that the one was left at Aberdeen and the other at St Ninians. I not only dressed wounds of all the wounded men and Militia prisoners at Stirling (which was the Place I was ordered to reside at) but likewise gave them money towards their substance, this can be attested by Mr Simpson, Minister of the Gospel at Falla, who was a Prisoner. I believe both he and Mr Matland will likewise attest the pains I was at to get a place for a Hospital to them where I might have them better taken of, both as to the Dyet and other ways, but the hurry and confusion the Rebels were continually in at that time prevented their doing anything of that sort, to either their own People or Prisoners. From their abandoning Stirling till now I was not of the smallest use to either side, having neither Instruments, Bandages, Dressings, or Medicines they having been left in Athole in the hurry of their Flight from Stirling, and brought again to Inverness by Lord George Murray a few Days before the Battle of Colloden. The Lord Presidents Chamberlain and other Servants can bear Witness to the use I designed them for that day.

Lochiel was slightly "wounded in the heel by a musket-ball during the heat of the action at Falkirk". As Dr Archie was lending Lochiel assistance he himself was wounded (loc cit, p 48). Shortly after the battle Lochiel was able to lead a detachment into the town of Falkirk.

James Farquharson, of Balmoral (Tayler, *Jacobites of Aberdeenshire and Banffshire of the '45*, p 170), was wounded in the shoulder at Falkirk. The wound proved more severe than at first thought, and he was forced into inactivity in Aberdeenshire—"He came to Perth right bad in a chaise" (Bisset's Diary, Feb 7, 1746).

In Stirling jail William Chrystie, Chyrurgeon, treated 26 prisoner-patients, of whom 16 were "fever" patients. Ten had gunshot wounds (2 of them with fractures), received during the Siege of Stirling Castle. In one case an amputation proved necessary, but ended fatally. The surgeon charged 6 shillings and 8 pence for the amputation—the same fee as for attending a fever case (<sup>31</sup>).

#### MALIGNANT FEVER (TYPHUS) AND 'THE 'FORTY-FIVE'

Typhus has been a scourge of Armies in the field for 500 years, and the Civil War of 1745 was no exception, the "malignant fever of the hospitals" was almost certainly typhus. The disease broke

out furiously among the infantry embarked in the Low Countries and landed at Newcastle, Holy Island, and Berwick in the autumn of 1745. The sick disembarked at Newcastle were lodged in a hospital (or house) which also received the sick from Marshal Wade's army, not only were the nurses and those constantly in the wards victims of the malady, but also the medical attendants. "Three of the town apothecaries, four of their apprentices, and two journeymen were seized with the contagion and died."

Though Ligonier's and Price's regiments left their sick behind at Antwerp, by the time the transports reached Holy Island 97 soldiers were already ill with "malignant fever", and no fewer than 40 succumbed. The inhabitants of Holy Island also caught the infection and 50 died—one-sixth of the population. There were fewer sick among the troops landed at Berwick, where the disease was apparently less severe and did not spread.

In December, 1745, an army of twelve battalions of infantry and three regiments of cavalry was assembling in the Staffordshire area under Cumberland. Pringle resolved on a policy of dispersal of the sick of this army, the men as they fell ill were left in the various towns under the care of the local surgeons and apothecaries. Apart from Lichfield, the men were not nursed in any common hospital, there was no epidemic and cases did well, "malignant fever" was unknown and there was no mortality. However, in Lichfield there were many more sick and the workhouse had to be fitted up as a hospital. "Too many cases were admitted, the air was corrupted, the common fevers became malignant and several died" (Pringle).

In Scotland until the outbreak of typhus in Inverness (see below) the diseases of the Army were chiefly respiratory infections. In the last three weeks of February, 1746, the Duke's troops were in billets in Perth, two battalions were quartered in churches. Pringle says "the hard coughs in particular with inflammations of the pleura and lungs were most frequent." Three hundred sick were left behind in Perth and Montrose in "Corporation Halls and private houses."

The Army was quartered in Aberdeen most of March, but subsequently a considerable proportion of the force was dispersed in Aberdeenshire villages. The men suffered from the extra cold, the easterly winds, cold beds, guards and out-duties and their own mismanagement, their ailments were the common winter infections. The officers fared better in warm quarters, and the respiratory diseases were not so frequent, but some of them developed gout (1).

In Aberdeen the sick were lodged in the hospital of the town (Aberdeen Infirmary) and in other large houses and escaped 'hospital fever'. Four hundred sick were left behind at Aberdeen, Inverurie, and Strathbogie, when the Army moved north, but only a small proportion died. Before Inverness was reached another 60 or 70 had fallen sick, apart from those wounded at Culloden, and were left in the townships and villages through which the Duke's Army passed.<sup>12</sup>

**Aberdeen**—During his occupation of Aberdeen, Cumberland converted Gordon's Hospital (Fig. 6) into a fort and garrisoned it with 200 men under

Captain Crosbie—with the object "of securing the town against any insults from Glenbucklet's people or any others who may have forebore showing themselves when we were here with the Army." Despite its name, the building was never intended for the sick, but had been erected in 1732 for the poor children of decayed burghers. There had been delay in using it, "since the expense of the building

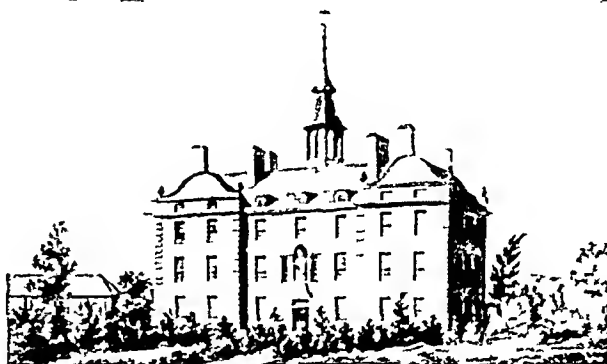


FIG. 6—Gordon's Hospital, Aberdeen, in the eighteenth century (called 'Fort Cumberland' in March 1746).

had materially encroached on the funds in their hands (the amount of which was originally £10,300), and owing to this and to the troubled state of the country in 1745 and 1746 the house remained unoccupied (*except that it was used as a barracks by the Royalist troops in 1746*) until 1750. The first occupants were the Hanoverian troops, who surrounded the building with a trench and earthen ramparts faced with palisades and christened it "Fort Cumberland." Doubtless "minor sick" were treated there.

**Inverness**—At Inverness two malt-barns were commandeered for the reception of the *Hanoverian wounded*, who numbered 270 in all. "There were many with cuts of the broadsword, till then uncommon wounds in the hospitals, but these were easily healed (1) as the openings were large in proportion to the depth, (2) as they bled much at first, and (3) as there were no contusions and eschars as in gunshot wounds to obstruct a good digestion" (Pringle).

In addition to these "wards" for the wounded, arrangements were made for the sick. Two "well-aired houses" were taken over for the more serious sick, the regimental medical officers had to find quarters for the less severe cases. It was hoped that these measures might prevent any epidemic which the conditions prevailing in Inverness appeared likely to favour. There was no outbreak until the arrival of Houghton's Regiment which had been sent up as a reinforcement. These had with them 36 deserters from English gaols for court-martial who brought "jail-fever" along with them. Three days after the coming ashore at Nairn 6 officers were seized with "jail-fever" and 80 men were left there with the same disease. During the ten following days that they were in camp in Inverness they sent into hospital 120 patients with the same fever. The symptoms and course of the disease left no doubt that "jail-fever" and hospital fever were the same, previous conjecture was now a certainty.



In Inverness, there were also frequent cases of slight *diarrhœa*, which Pringle thought might be the result of the Ness water which had always been accounted a laxative to those unaccustomed to drink it. These cases either cleared up quickly or yielded to astringents. When a force left Inverness for Fort Augustus, 600 sick were left behind (excluding the wounded). In Fort Augustus and Fort William there were "*dysenteries, fluxes and agues*"

A note in *More Culloden Papers* details the buildings utilized by the Hanoverian sick and wounded, which involved very considerable expense to the town of Inverness —

Repairs and conveniences made for the King's Army after their entering the Town the 16 April 1746 immediately after the Battle of Culloden

Repairing glass work of Charity School, Library & Achnacloch's kiln used as *hospitals* by the Army

Clerk MacBean's house also taken for a *hospital*  
Fairfield's kiln fitted also for a *hospital*

A description of typhus cases in Blair Castle and of the overcrowding which led to its spread is to be found in the account of a *Surgeon attached to the Hanoverian Army*

On the Jacobite side there was little illness or accident during the period of invasion of England. In the *Lockhart Papers* there is a statement attributed to Lord George Murray that "by all accidents such as death by sickness (of which it is believed that there was more in one day in General Wade's Army than were in six weeks in His R H s) we did not lose forty men in the whole expedition including the 12 at Penrith"

## THE NATURE OF INJURIES IN JACOBITES WOUNDED AT CULLODEN MOOR

The types of wounds in those recovering may be gauged from the following extracts, they include through-and-through wounds, retained fragments, compound fractures with osteomyelitis, head wounds, etc., and contusions

*Cameron of Lochiel*<sup>11</sup> "As the action was near over, Lochiel was wounded in both his legs. He was carried out of the field by four of his men who brought him to a little barn", later on they "put him on a horse, and brought him to Clunie's house in Badenoch, where he continued till next morning and then went to Lochaber. When he left the barn he dismissed two of the four men, the other two supported him on the horse"

"Breackachie informed me that Lochiel was quite out of all danger as to his wounds when Sir Stewart Threipland (alias Dr Threipland) left Badenoch, which was some time in the month of July 1746. 'But then', added Breackachie, 'Lochiel's wounds were not entirely closed up, neither was he free of pain, when the Prince came to Badenoch, at which very time Lochiel was not able to walk well about, but behaved to be removed about from place to place on horseback. However, before notice came of the two ships on the west coast, Lochiel's wounds were quite closed up and skinned over, and he was then fit to travel' "

*Captain Roy MacDonald*<sup>12</sup> was bid by the dying Keppoch "Do the best for yourself, for I am gone", and in walking off the field received "a musket bullet in at the sole of the left foot and out at the buckle, and yet that day he walked five miles without stopping (the foot bleeding all the time and the wounds being

altogether without any dressing or so much as a rag about them) to a place two miles beyond Inverness called Bunchrive, where he got a horse and rode eight miles the same day, always pushing his way towards the Isle of Skye, where he was very desirous to be. "He durst not put the wounded foot into a stirrup, it was swelled so big, and he had no shoe upon it, for he had lost the shoe when he got the wound"

Next day, Thursday, April 17, he luckily fell in with one, Balfour, a young man (who had been surgeon to the MacGregors in the Prince's service and who was taking care of Murdoch MacLeod of Raasay). "This Balfour dressed the foot by only putting some dry tow upon the hole beneath and the hole above and rolling a bandage above all. The foot got no more dressing till he came upon the Isle of Skye, being Wednesday April 23rd, eight days after the battle." "He took up his quarters in the house of John MacLean, surgeon in Troternish, and had the foot dressed for the second time upon the Wednesday April 23rd, and by this time it had such a stink that one could scarce enter the room where he was." The story is somewhat reminiscent of Philoctetes, except that for a time he "continued in the surgeon's house. Later the Captain had three different caves, where by turns he made his abode for eight weeks, and during that time Lady Margaret (MacDonald) furnished him with provisions and necessities, and the surgeon forgetting ancient clan prejudices used to send dressings to him for the wounded foot, by a proper hand. In the caves he had beds only of ferns or heath, and wrapped himself in his tartan plaid. The midges and flies from the heat of the season (part of July and August) proved very uneasy companions to him, which obliged him frequently to retire into the inner parts of the caves, where the coolness kept them from him." The wounded foot took long to heal and sequestra were discharged, but ultimately a good result was obtained. "The rain was exceedingly heavy, and dangerous to the wound in his foot, which was still open, and was not quite healed up till sometime in November, 1746, it continuing all that time (now and then) to throw out small bones. He now walks as cleverly as ever without any the smallest pain or halt, and made a journey from Skye to Edinburgh in twelve days on foot, and as he came along visited several friends and acquaintances"

Captain MacDonald brought to Edinburgh a Latin ode to his wounded foot written by John MacPherson, Presbyterian preacher at Sleat in Skye, which appeared in the *Scot's Magazine*, December, 1747 (*Lyon in Mourning*, 2, 37). The poem is too long to reproduce here in full, but one stanza describes in detail the anatomical nature of the injury and the loss of his shoe

*Non modo carnes, gracilesque fibras,  
Tendines, verumque laceravit ossa,  
Calceo secta ligula repente  
Me spoliavit*

*Captain MacDonald, of Belfinlay*, "who was 18 years old and an officer in the Highland army, has the misfortune to be shot through the two legs in that action which rendered him incapable to make his escape. He lay in a field after he received his wounds, and was betwixt the fire of the English army and that of the few French troops that made some resistance after the Highlanders were routed, where showers of balls pass'd by him. He remained likewise in the field all that night after he was stript of all his cloaths, his very shirt and breeches being taken from him. He lay a prisoner at Inverness, not being able to be transported with the broken bones in his legs till the indemnity which set him free"

Further details of Belfinlay's compound fracture of both bones of the leg are forthcoming, the injury was produced by "small shot out of the belly of a cannon", and a metal fragment was extracted. In February, 1749, 24 sequestra had extruded themselves, and during

April, 1749, 2 more splinters were pointing and he was confined to his room in the Canongate, Edinburgh

Belfinlay recovered "the use of his legs so well that in his journey to Edinburgh he walked from his own house to Inverary, being no less than sixty long miles, but he is still afraid that there are some more splinters of bones to be taken out. He is a tall, strapping, beautiful young man, but has contracted a delicacy of constitution with his sufferings"<sup>11</sup>

*John Fraser*, Ensign in the Master of Lovat's Regiment, was shot through the thigh by a musket bullet at the Battle of Culloden, and the following day Fraser received further injuries from one of Cumberland's soldiery, who, with the butt of his gun, struck him on the face, dashed out one of his eyes, and beat down his nose flat and shattered to his cheek. Fraser was taken to some place of concealment and recovered from his wounds

I likewise asked him about the wound he had received in the action at Culloden. He told me that the bullet entered at the left shoulder, and lodged under the right shoulder blade, and that one, Balfour, a surgeon, took the bullet out the day after the battle<sup>11</sup>

*Dr Murdoch MacLeod*,<sup>11</sup> Raasay's third son, was at Kinnag when Captain Roy MacDonald arrived there, he had received a musket bullet in at one shoulder, and which had made its way under the skin by the root of the neck to the other shoulder where it lodged. At Kinnag, Mr Balfour made incision upon the shoulder and took the bullet out. Malcolm MacLeod and his wife and Murdoch MacLeod accompanied Donald Roy MacDonald to the "ferry at the head of Loch Terran, where they parted, they sailing for the Isle of Rasey". Belfinlay said that *Robert Nairn* (? Thomas) was among the wounded who had got off from the field of battle, Nairn's legs being quite safe, but one of his arms was almost cut off with wounds, that the said Nairn was his fellow prisoner in the same room with him, and that Nairn (when pretty well recovered) made his escape out of the said room. Belfinlay added that Mr Nairn had almost died of a mortification in his back, when bedrid in his wounds, and he believed Mr Nairn would never have the right use of his wounded arm<sup>11</sup>

There are few details about *Captain Allan Cameron*<sup>11</sup> of *Collart's* injuries at Culloden, save that he had a broken arm and though brutally treated in a prison ship on the way to London, he recovered. *Thomas Fraser*<sup>11</sup> (or *Frazer*) was shot through the thigh, he escaped and recovered. *Patrick Fleming of Auchintoul*<sup>10</sup> (14th Laird), said to have been the best swordsman in the Prince's army, received a gunshot fracture of the leg at Culloden. Feigning death, he endured the agony of having his boots dragged off by the Hanoverian soldiery. Fleming recovered

"That in the same country house the said Lauchlan Grant did see likewise, at the same time, another man<sup>11</sup> whose head he (Lauchlan Grant) believed was cloven to the harns, and whose tongue was so hanging out that the poor man himself could not put it in again. But Lauchlan Grant put in the poor man's tongue, and tied a napkin about his cloven head, upon which the poor man thanked Lauchlan Grant in Erse, and prayed God to reward him"

*John Tyrie*, a priest, was twice wounded in the head, but escaped capture

*John Macdonald of Leek* was wounded in the thigh at Culloden and remained six months in the house of Grant of Glenmoriston 'till his wound was healed. Later on he joined the Fraser Highlanders and survived 'till 1813

The 16th *Clan Ranald* was wounded in the head at Culloden, and escaped to his grandmother's house in Inverness, whence for his greater safety he made his way to Moydart. With Kinloch Moydart he had come aboard the *Du Teillay* in the summer of 1745

*MacLeod of Glendale's* son, who had sailed to Scotland with the Prince as his aide-de-camp, was wounded at

Culloden. One of his son's ultimately practised as a physician in Harris

*Macdonald of Dalchosme* was killed at Culloden, his eldest son died of wounds at Dalchosme. A daughter, Barbara, who led an anxious and strenuous existence in 1746, taking food to her brother John, in hiding, lived to be 91

*Hugh Fraser*, at one time secretary to Lord Lovat, who turned King's Evidence against his master, had a certificate issued on his behalf by *Arthur Baynes*, a surgeon in Inverness, dated August 22, 1746, to the effect that Fraser "has several bones to come out of his Arm and is in a bad State of Body otherwise, being much weakened by violent sweatings and looseness for these three weeks past", and that it would be dangerous to move him. Fraser was sent by sea to Edinburgh in November and by road to London in December. On May 25, 1947, there is a report from Dr Freeman of Conduit Street, London, that "ye gross Neglect of his former Surgeons had rendered impossible a total Recovery of his Arm". However, he says that his own skill has been the means of restoring some function to his hand and fingers. Finally, he suggests a visit to Bath as a means of rehabilitation. King's Evidence apparently opened the door to skilful methods and even fashionable places of treatment (!)

"Nursing" After Culloden—Mrs Ann Leith,<sup>10</sup> who has been described as the Florence Nightingale of the Rising, apparently came from Strathbogie. She and her maid, Effy, set out on the morning of Culloden with the object of taking food, etc., to friends in the Highlands Army, which she knew to be terribly short of food. From April 17 to July 29 she was "never two hours at a time in my own house, but while I slept, still going from person to person and from one great person to another soliciting favours for the destrest". She appealed to Lord Lewis Drummond and the Marquis d'Egouilles who were prisoners on parole, to use their influence with Lord Cathcart, Lord Albemarle, and Captain Collingwood

She was herself arrested by Captain Eyre, when on her way to visit and succour her personal friends, but was released by General Huske's orders. Mrs Leith was a cousin of Gordon of Glenbucket and was specially kind to his blind eldest son when the latter was a prisoner in Inverness, even lending him money which apparently was never repaid (!). The cause of "Colonel" John Gordon's "threat and blindness" is stated by Lord Elcho to have been drink, but this seems very improbable. In January, 1749, she writes that she herself had been "dressed with the Rheumatism in my limbs that I can hardly make a street length at any time"

## THE PRINCE'S HEALTH AND ILLNESSES IN 1745-6

Until the Battle of Falkirk the Prince displayed the tireless energy and indefatigability of youth. He walked the Corriearrick Pass at such a pace that the Highlanders were glad when he lost the heel of one of his brogues (*Lyon in Mourning*, 208). *The Lockhart Papers* (2, 498) also refer to his walking powers, even at night. "one of the darkest nights I ever saw, yet did His R H walk it on foot, and most of the way without a lanthorn, yet never stumbled which many of us Highlanders often did". This refers to a march from Penrith to Carlisle at night. During his wanderings after Culloden he

smoked a lot (*Lyon in Mourning*, 177), the pipes often broke and he put quills into one another to make the stem long enough, and "the tobacco smook cool"

The Prince caught a severe cold after Falkirk and remained at Bannockburn House (Fig 7),

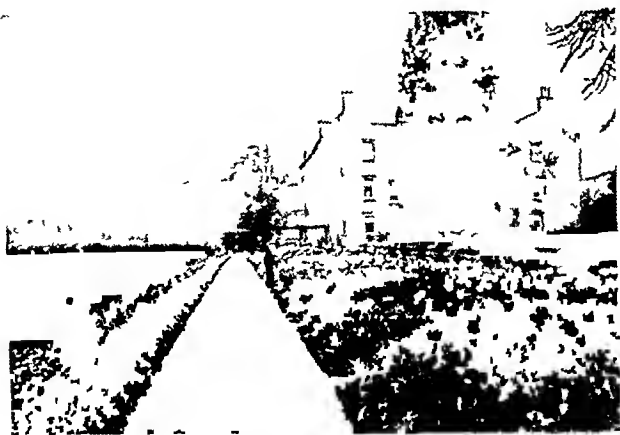


FIG 7—Bannockburn House, where the Prince was ill, January 1746 (By courtesy of Miss Wylie)

where he was nursed by Clementina Walkinshaw during the last weeks of January. His cold never got quite well and flared up again after the surprise attack on Moy, and he finally developed pneumonia.

Some extracts from Sullivan's Diary reproduced below from Henrietta Tayler's 1745 and *After*<sup>9</sup> instance the maladies from which the Prince suffered during the period immediately before Culloden and while he was "skulking" in the West and in the Isles. The first two references (pp 143, 144) concern his illness in Elgin when he was nursed at Thunderton House (Fig 8) by Mrs Anderson, of



FIG 8—Thunderton House (From an old print)

Arrandour. Despite Sullivan's mention of spotted fever (loc cit, 143), there can be little doubt that the Prince had pneumonia. Henrietta Tayler draws my attention to the fact that Mrs Anderson carefully preserved the bed-clothes in which the Prince slept which she would scarcely have done if typhus had been the ailment in question. The incident (loc cit, 181) refers to the visit to Stornoway after a difficult march in the Long Islands. The Prince apparently had "a form of dysentery throughout his

wanderings, but regarded the laxity of his bowel as due to milk (!) and to the lack of alcohol, had great confidence in the curative properties of treacle which Sullivan managed to produce and which had the desired effect. Henceforth he would have no more milk. The extract (loc cit, 188) shows that he did not suffer from scabies—a ubiquitous scourge in Scotland at that time. The Prince was in poor general condition when he finally got back to Paris, even worse than when Sullivan left him in the end of June.

HRHs was very ill at this time with a spotted fever, but it was kept so secret yt Sullivan knew nothing of it until night, yt Sr Thomas made him a confidence of it. The Prince happily recovered'd a most violent & dangerous favour & got up the ninth or tenth day, against the Doctors advise, being still in the favor, & said yt peoples were sick, only when they thought themselves so, they starved him almost, giving him but very light broaths, but when he got up, he wou'd eat a soupe, the next day eat something else, the Doctors were mad, thought he d Kill himself. In three days after the Prince arrived at Inverness, as well as cou'd be expected, after such a sickness, but very low. a furiose weave comes & throws the Prince flatte again the other side of the boat, the Prince crys out "there is no hurt, there is no hurt" Sullivan & o'Neil goes to help him up, another weave comes throws them all three one upon another. I declar to yu the Prince was blew with cold, & so was every body. The Prince was in a terrible condition setting aside cold & hunger without even complaining, he had not a Shoe to his feet, all tore to pieces, they held only with cords yt they tyed up wth, his toes were quit stript. But as the milk did not agree wth him, & yt he had no other kind of Liquor, he took a looseness, wch turned to a bloody flux. He'd not let a soul know this but old Sainclair, he grew so low & so peal yt Sullivan was frightend "if I had traicle, I'd be cured immediatly" Sullivan remembred yt he had a little pot yt he carryed about him when he was ill himself, went immediatly & found it, the Prince took of it, with a little broath, & in three days time the flux caussed. The Prince drank no more milk, lived upon watter & was perfectly well. Glenarandol came to joyne here, & brought him, where wth all to make him a surtout of good English Cloath, When the Prince got on his highland Cloaths he was quite another man. "Now," says he leping, "I only want the Itch to be a compleat highlander." He was in a frightfull condition as those gents says when he arrived aboard the ships, not only his feet all cut & stript, but his legs & thyes in ulcers, even worse then he was when Sullivan quitted him. nothing left but the wig, wch was a most abominable one, but a Lady discover's it was not given away, but thrown aside, & she wou'd have it. She was told it wou'd infect her, yt it was full of vermine, as really it was, & never such a one was set to frighten Crows away, but she got it, & set it up pretiously, as the rest was by those yt had them.

## THE ARMAMENTARIUM OF THE SURGEON OF 'THE 'FORTY-FIVE'

For surgeons in the field Ranby's *Method of Treating Gunshot Wounds*, published in 1744, must have been not only the most modern but the most convenient in size. It is difficult to imagine the conveyance by Army surgeons of such volumes as the sixth edition of Wiseman (1734) or the English translations of Dionis (1710), Garengot (1723), or Heister's compendium (1743).

The instruments available for the Army surgeon are detailed in the Preface to Ranby's book (Fig 9).

Some information regarding the nature of the drugs employed in Scotland at the time may be found in the contents of Prince Charles's Medicine Chest and the cost to the patient of medicines, etc., supplied can be ascertained by reference to accounts submitted by surgeons of the time. The details of an account for medicine, etc., supplied by Alexander Monro, sen, to Duncan Forbes, of Culloden, just prior to the period under consideration are not without interest (*More Culloden Papers*, 223).

Paucity of space precludes me from appending a complete list of the contents of Prince Charles' Chest (Fig 10). It was not devoid of humour that the contents of a phial marked "9" were Glauber's



salts The smell of ammoniacum was still distinctive after 200 years *Argent viv* in the list is clearly quicksilver, and *Aq Reginae Hungar* was made from rosemary in blossom, sage, and ginger cut in pieces, and water and rectified spirit were added This was used as a perfume, but also employed as a

The diarist complains that on a Sunday "he stopped at the post house for refreshment, but could have nothing but an egg or two with some wine or thick Scots ale, it being a custom through many parts of Scotland to eat only an egg or nothing for dinner, and to have a hot supper at night"

THE  
METHOD  
OF TREATING  
GUNSHOT WOUNDS

BY  
JOHN RANBY,  
Principal Surgeon to His  
MAJESTY and F.R.S

LONDON  
Printed for JOHN and PAUL KNOTTON  
in Pall-mall in Maccles

## THE PREFACE

A Screw Saw with two Blades  
A Knife and Catlin  
An Artery Forceps  
Two Cauteries  
Four Chisels, large, and of different Figures  
A Trephine, with two Heads and a Key  
A Perforatory  
A Lenticular and Raspatory  
A Case of crooked Needles  
A large, and small, Catheter  
Crooked Scissors  
Two *W/balebone Probes*, { *7 1/2 inches long*  
A Steel Probe { *10 1/2 inches long*  
A Speculum Oris  
A Plaster Knife

## THE PREFACE

A Trocar  
Paces  
A Brush for the Trephine  
A Bar Instrument with two Claws  
Bullet Forceps, twelve Inches long, with four sharp Teeth  
Ditto, straight, without Teeth  
A Levatory  
A Screw Tourniquet  
A Case of Pocket Instruments  
A Case of Lancets

THE Hospitals are not only furnished with these, but thro an abundance of Care and Tenderness for the Patients supplied likewise with several very curious additional ones,

A

FIG 9—Title page and preface from Ranby's *The Method of Treating Gunshot Wounds*

restorative in faintness *Lapis infernalis* was nitrate of silver, "*dragon's blood*" was given as a mild astringent and was one of the ingredients in the styptic pills of Helvetius *Elixir of vitriol* "mightily strengthens the stomach and does good service in relaxation for debauch and overfeeding" *Sal succini* was used in rheumatism, gout, suppressed or

He also refers to the washerwomen treading the soiled linen in a tub with their naked feet on the banks of the River Ness, at the same time holding their petticoats up to their middle Human nature does not change much with years, for the surgeon

Account for Medicines, Etc, supplied by Alexander Monro, Surgeon-Apothecary, from 1724 to 1744

Accot the Right Honble my Lord President to Alexander Monro, Surgeon-Apothecary

			£	s	d
1724					
Jan	26	Item a vomit for Mrs Wilson	0	0	6
April	2	Item a vomit for your son	0	1	0
Sept	1	Item a Dose Sacred Tincture	0	1	8
1728					
June	19	Item to himself Diachylon Plaster	0	0	10
		Item a large Pot Basilicon Ointment	0	1	4
1731					
Aug	10	Item some Red Precipitate of Mercury	0	1	6
1732					
April	30	Item Gold Leave 12 in number	0	2	0
1736					
Jan	10	Item a Paregoric Haustus	0	0	9
1738					
Sept	12	Item a Dose Sacred Tincture	0	1	10
1744					
Jan	22	Item to the Cook a Dose Salts	0	0	10
Sept	1	Item for the Footman's Child a vomit	0	0	8
Feb	8	Item for the Postilion a dose Physic	0	1	3
Mar	18	Item to the Cat a vomit	0	0	2

repressed eruptions and cramps, *Pil e styrace* was useful in chronic coughs and some other pulmonary affections, etc, etc

In a *Journal of an English Medical Officer who attended the Duke of Cumberland's Army as far North as Inverness*, published in 1746, there is a note about the Scottish Sabbath, which, in fact, did not differ greatly in the end of the nineteenth century

adds that the "river edges are lined with these sort of women that are maid servants and frequently as many soldiers admiring their legs and tighs"

One's own county pride is hurt by a reference to a disorderly house on the road out of Aberdeen towards Inverness "we pass through several



FIG 10—Travelling medicine chest of Sir Stuart Threip-land, commonly known as Prince Charlie's medicine chest. The original is in the Royal College of Physicians, Edinburgh (From Comrie's *History of Scottish Medicine*)

small villages amongst which is Newkirk\* noted for a famous (? infamous) house kept there by an old woman and her two daughters "

### EPILOGUE

I am not concerned with the political implications of the '45, nor can I claim any Cassandra-like gift of prophecy as to what might have been the final result, if this or that policy had been adopted or rejected by the Jacobite leaders in the field. The late Lord Rosebery has recorded his opinion that "in all probability, had Charles not retreated from Derby, ten thousand Frenchmen would have attempted a descent on Southern England and changed the face of our history "

Militarily, the Jacobite Rebellion may have been only an episode or diversion in the war of the Austrian Succession, one of the long series of wars in which Britain tried to prevent France from regaining paramount power in Europe, but also the Rising was the last spark of the flickering Stuart story—"a Cause for which thousands of men willingly and devotedly faced exile and ruin and death, round which some of the sweetest poetry of Scotland has twined itself, and which the legends of the Scottish people still embalm "

But for a year Scotland was torn and riven in the throes of civil strife, clan was divided against clan, family against family, father against son, or wife, brother against brother. The first lines of Lucan's "Pharsalia" are no exaggerated description of the regretful picture of Scotland's agony

*Bella per Scoticos plus quam civilia campos  
Iusque datum sceleris canimus populumque potentem  
In sua victrici conversum viscera dextra,  
Cognatasque acies*

To-day is Culloden Day, and 199 years ago on this afternoon Prince Charles was in flight to Gortuleg, destined to spend another five months in Western Scotland and the Isles in his endeavour to reach France, doomed to communion with his own thoughts over the ruin of his Cause and the disaster and death of many of his friends, but still supported by the hope of a to-morrow. His reverie and regrets are expressed by Scotland's poet in "The Chevalier's Lament "

The small birds rejoice in the green leaves returning,  
The murmuring streamlet winds through the vale,  
The primroses blow, in the dew of the morning,  
And wild scatter'd cowslips bedeck the green dale  
But what can give pleasure, or what can seem fair,  
While the lingering moments are number'd by care?  
No flowers gaily springing, or birds sweetly singing,  
Can soothe the sad bosom of joyless despair

But 'tis not my sufferings thus wretched—forlorn,  
My brave gallant friends! 'tis your ruin I mourn,  
Your deeds proved so loyal in hot bloody trial—  
Alas! Can I make you no sweeter return?

For more than 300 years before the '45 discerning men had seen that Nature designed the inhabitants of the isle of Britain to be citizens of a single nation, a consummation too long delayed and now opposed for the last time by the Clans under Prince Charles and against the will of a pacific majority in Scotland

The little Jacobite rose of purest white, emblem of unswerving loyalty and selfless devotion, still grows on Scottish doons and in Scottish gardens, and in the grounds of Elrick, Aberdeenshire, there is a Jacobite rose tree sent years ago all the way "from the garden of Charles Edward's villa in Rome as a gift to the lady of Nethermurlands (Elrick), a great politician in her day and a great Jacobite"<sup>18</sup> A century or two is as nothing to a rose and to this day (1899) it is hale and hearty. The original tree is now dead, but a shoot from the tree was graciously accepted for Balmoral by Her Majesty, one of whose ancestors lost his life on the Jacobite side in the Rising of 1715, though none of the Lords Strathmore took an active part in the '45. The shoot from the rose tree of Charles Edward's garden has now fresh roots in the Balmoral Garden of Her Majesty, the most honoured and the most adored of all descendants of those who once wore the white cockade.

It has not been easy for one playing some surgical share in the prosecution of this war, and at the moment shouldering other burdens perhaps less intimately connected with the war effort, to find the necessary time for the preparation of an historical lecture, but my labours have been lightened by the readiness to help so uniformly and so willingly demonstrated by all to whom I have made appeal. There is, of course, much literature dealing with the '45, and there is abundant reference to this in the bibliography at the end of the paper, but one of the authors whose name must recur with inevitability whenever the '45 is under discussion is deserving of my special gratitude—Miss Henrietta Tayler, perhaps the greatest living authority on the Jacobites of the first half of the eighteenth century, who has helped with her counsel, literary material, and several illustrations.

My friends, W R Le Fanu and Samuel Wood, of the Library of the Royal College of Surgeons of England, have afforded me most valuable aid, and G F Home and W J Bishop, of the Library of the Royal Society of Medicine, have been no less eager and anxious to furnish assistance.

Across the Border, where the subject always seems to make a special appeal, I am under a deep obligation to many. In Aberdeen, the Lord Provost and Town Council graciously permitted me access to the records of the proceedings of the burgh at that time, and my special thanks are due to Mr D G Gunn, the Town Clerk, an office which my uncle, the late Dr William Gordon, held for nearly half a century. The Board of the Aberdeen Royal Infirmary courteously facilitated my efforts, and I would specially thank the Medical Superintendent, Dr Knox, Dr Alexander Lyle, and Mr John A McConachie, the Clerk and Treasurer.

No one appeals in vain to the learning of Dr W Douglas Simpson, Librarian, King's College, Aberdeen, the Headmaster of Gordon's College, and Mr Walter R Humphries, H M Inspector of Schools in Scotland, have not only furnished me with valuable information about the part played by my old school in the Rebellion, but have even gone to great trouble over other inquiries relevant to my subject.

My friend, Mr A J C Hamilton, F R C S, of Inverness, through contacts made for me, has greatly facilitated my labours in that city.

\* Newmachar

In Edinburgh, the Librarian of the Royal College of Physicians, Dr T H Graham, was himself a storehouse of lore and a skilful guide to other possible sources of information, and I cannot forget the kind help of Mr W J Stuart, F R C S, and Professor J R Learmonth, C B E, of Edinburgh University, Mr J R Richardson, F S A Scot, A R I S A, Inspector of Antiquities, National Museum of Antiquities of Scotland, those in charge of the Signet Library, the Keeper of the Burgh Records, the Keeper of Manuscripts, National Library, and Mr David Band, F R C S

Such medical historians as Lord Amulree, Professor Hume, of Newcastle-on-Tyne, and Dr Douglas Guthrie, of Edinburgh, kindly helped my unsteady footsteps on the track of history. My old 'shipmate', Surgeon-Lieutenant A M Gilchrist, skilfully directed my steps in Glasgow, and finally, from Mrs Burnet Whyte, of Elrick House, Aberdeenshire, I have learned much about the Jacobite Rose, the illustration of which has been kindly supplied by Mrs Coulson, of Duff House, Arundel.

The notes on the medical and surgical aspects of the '45 have been excavated by hard endeavour from amidst material less relevant to my inquiry, collected in fragments, and hastily and imperfectly pieced together in this address. The motto of the Scottish History Society must be my excuse for this presentation —

"Colligite fragmenta ne pereant"

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## THE IMMERSION FOOT SYNDROME

By C C UNGLEY, SURG COMMANDER, R N V R, G D CHANNELL, SURG LT COMMANDER, R N V R,  
AND R L RICHARDS, E M S, SCOTLAND

THE term 'immersion foot' was coined during the present war to describe a syndrome occurring in extremities exposed to the effects of cold sea water. It is a disorder characterized by chilling as opposed to freezing of tissues and is distinct from frost-bite. The term is neither accurate nor adequate, since the syndrome may arise without immersion and may affect the hands. The condition is most frequently seen in shipwreck survivors who have spent many hours in water-logged lifeboats or clinging to rafts, but may result from any circumstances in which there is prolonged exposure of the extremities to the effects of moist cold. The alternative "peripheral vasoneuropathy after chilling" suggested by Ungley and Blackwood (1942) is a more accurate term, but lacks the simplicity of "immersion foot", and the latter has now been generally adopted in both this country and America.

It is certain that immersion foot is not a new disorder. Although prior to 1940 there was a remarkable dearth of medical literature upon the subject, the condition must have occurred from time immemorial amongst seafarers and others exposed to the effects of cold and wet. Critchley (1943) has collected evidence of the occurrence of immersion foot as early as 1727, and quotes several instances where swelling and gangrene of the feet were recorded in shipwreck survivors and Polar explorers. Two factors have contributed to previous lack of recognition of the syndrome: (1) In peace-time shipwrecks occur near land or on recognized sea routes and the survivors are rapidly rescued, and (2) There has been a tendency to confuse the condition with frost-bite. This confusion persists even at the present day (*see* Brownrigg, 1943).

Descriptions of trench foot as it occurred in the last war (Cottet, 1917, Grattan, 1922, Thompson, 1937) and in the recent Spanish Civil War (Fievez, 1939, Rabut, 1939, Monsaigneon, 1940) present a clinical picture similar to that of immersion foot, and the two conditions are certainly akin, if not identical. An early case of immersion foot was about to be recorded as a case of trench foot in a sailor, when in June, 1940, survivors from the aircraft carrier *Glorious* reached a naval hospital labelled 'immersion foot'. The identity of the medical officer concerned has not been established, and Greene (1941) used the term in print for the first time. Subsequent descriptions of the syndrome have been published in this country by Ungley and Blackwood (1942), Ungley (1943, c), Critchley (1943), and Goldstone and Corbett (1944), and in America by Webster et al (1942), Brownrigg (1943), and White (1943, a).

## CLINICAL FEATURES

The features of the syndrome may conveniently be described in four phases—

1 **During Exposure**—Survivors state that during exposure the affected limbs are numb and

powerless and feel absent. Pain is seldom felt, but the limbs may be tender and occasionally muscular cramps are experienced. Tingling and itching are rare complaints. Although it may have been present earlier, swelling is not noticed for some hours or days, boots may become tight, are removed, and then cannot be replaced. In very cold water the immersed limbs are a bright red colour, and this colour persists if sea water temperature is in the neighbourhood of freezing-point ( $-1.9^{\circ}\text{C}$ ). At higher temperatures the limbs appear yellowish-white, blue, or mottled blue and black. During exposure blistering is uncommon, but the cold sodden tissues are friable and minor injuries may cause serious damage.

2 **Pre-hyperæmic Stage**\*—This phase is a direct continuation of the events occurring during exposure. For some hours after rescue the feet remain numb and feel heavy. Survivors are frequently unable to maintain their balance or, if able to walk, they describe the sensation as "walking on air" or "walking on cotton-wool". Ankle and toe movements are absent or impaired. There is a 'stocking' type of sensory disturbance varying from hypæsthesia and hypalgesia in mild cases to complete loss of all forms of cutaneous sensation in severe cases. In the early stages it is common for sensory loss to extend as high as mid-calf. Joint sense may be lost in the toes and ankles. The chilled portions of the limbs remain cold and are pale, blue, or mottled. Severe cases may show large black, blue-greenish, or yellowish patches on the legs. Swelling depends upon severity of exposure, but a tense œdema often extends to above the knee. In this phase blistering is still unusual and it is difficult to be certain of areas that are to become gangrenous. Except in very mild cases, pulsation is absent in the peripheral arteries (posterior tibial, dorsalis pedis) and the cutaneous circulation, as tested by blanching with finger pressure, is very sluggish.

3 **Hyperæmic Stage**—Within 2–5 hours of rescue in the average case there is a remarkable change in the condition of the limbs. The previously cold, pulseless feet rapidly become hot and flushed and the pulses are full and bounding. Delay in the onset of this hyperæmic phase may occur in seriously ill patients, but the delay is of

\* In our Base hospitals there were few opportunities for observing the earliest stages after rescue, but much information was given by medical officers of ships. Our description of the pre-hyperæmic stage and of the transition to the hyperæmic stage is based chiefly on the findings of one of us (G D C) in 26 merchant seamen picked up by a destroyer in the North Atlantic after having been adrift for 10 days with sea temperatures of  $7.1-7.7^{\circ}\text{C}$ , and air temperatures  $8.8-12.0^{\circ}\text{C}$ . The early changes in limbs proceeding to extensive gangrene were described in a personal communication (1942) from Dr S Bartlett, of the Isle of Barra.

little prognostic value. The onset of the hyperæmic stage may be accelerated by warming the feet, a procedure that we unreservedly condemn.

With hyperæmia comes pain. In all but the mildest cases this pain is severe, burning, or throbbing in character, and increases in intensity to reach a maximum in 24–36 hours. It is a continuous diffuse pain and may be referred to blistered areas or areas of incipient gangrene. Patients are restless and require large doses of sedatives and analgesics. After 48 hours the pain may abate, but in some cases it persists and may be severe for weeks. About the 7th to 10th day after rescue pains of another type develop. These are shooting or stabbing pains not unlike the lightning pains of *tabes dorsalis*, and occur in bursts like machine-gun fire radiating from the centre of the foot outwards, usually to the tips of the toes. These pains are aggravated by heat and relieved by cold; they are most severe when the feet are dependent, after exercise, and when the feet are warming, e.g., after getting into bed at night. Exceptionally, attacks of stabbing pain may be precipitated by micturition, defaecation, coughing, or yawning. The pains and tingling gradually diminish in intensity and disappear within 6–14 weeks, but recurrences are not uncommon, even years after exposure.

If pain is the most prominent symptom of the hyperæmic phase, heat and redness are the most prominent signs. The sudden hyperæmia begins proximally and spreads distally to reach the digits within an hour. When fully developed, the area of hyperæmia does not correspond to the distribution of any nerve or blood-vessel, but frequently is related to the average level of immersion or to the uppermost level of colour and temperature changes noted on rescue. At first the redness is not general, some areas may remain blue in colour but feel as hot as the adjacent flushed skin. Fifteen to 24 hours after rescue, the hyperæmia is at its maximum and the limb has a somewhat 'beefy' appearance.

pulsation returns to the peripheral arteries and rapidly becomes full and bounding. After 48 hours continued absence of pulsation may be looked upon as a grave sign, but it is possible for one of the two main pulses (dorsalis pedis or posterior tibial) to remain absent without the development of gangrene. Collateral pulses such as that in the perforating branch of the peroneal artery in front of the lateral malleolus may be felt. When the legs are horizontal, the feet are pink with a bluish tinge; on dependency they congest rapidly and on elevation blanch almost instantaneously, the veins emptying rapidly and forming concave channels on the surface of the foot. The capillary circulation remains sluggish even after hyperæmia develops, but later the return of colour after blanching may be more rapid than in a control limb. In some cases it may be impossible to blanch certain dusky areas, in these the cyanosis is due to de-oxygenated blood that has leaked into the tissues through damaged capillary walls.

Swelling increases with the hyperæmia, and tense œdema which does not pit readily on pressure develops. The œdema fluid is of high protein content and is not a simple subcutaneous transudate (Richards, 1944). Blisters and ecchymosis develop with the increase in swelling. The amount of blistering appears to depend upon the rapidity with which the hyperæmia develops. Blistering is commonest over areas where the skin is lax—i.e., on the dorsum of the foot and toes and on the calf. Gangrenous areas may blister extensively. Fluid from blisters is glairy or straw-coloured, and has a protein content similar to that of blood-serum.

As hyperæmia develops, there is a rapid recovery of sensation. After 12 hours limbs that were insensitive as high as the tibial tuberosity will show only a 'sock' or 'slipper' type of sensory loss and the areas that have regained sensation may be hyperæsthetic and acutely tender to pressure so that they are intolerant of the touch of bedclothes or dressings. Within 7–10 days of rescue a relatively stationary

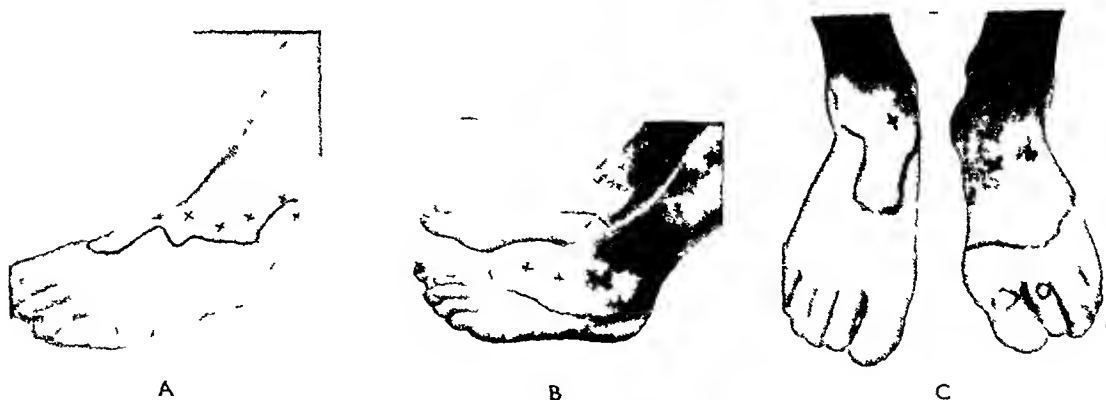


FIG. 11.—Photographs to show the distribution of anæsthesia (continuous line), analgesia (crosses), and anhidrosis (chinzarin method) in a moderately severe case of immersion foot (Grade B III). A, At 38 days after rescue, B, At 49 days after rescue, C, At 90 days after rescue.

Areas that are threatened with gangrene do not become warm, but the hyperæmia is intensified around them, forming a distinct line of demarcation.

At this time there is every evidence of an exceedingly active circulation. Within 2–8 hours of rescue

sensory picture is obtained. There is loss of all modalities of sensation over a variable area of the feet and toes. Typically the loss is of 'sock' or 'carpet-slipper' distribution, but not infrequently additional areas of anæsthesia are observed over

pressure points such as the malleoli. As a rule, analgesia is slightly more extensive than anaesthesia. Once this state is reached, further recovery of sensation is slow and is dependent upon the regrowth of nerve-fibres. The progress of sensory recovery in two typical cases is shown in Figs 11, 12.

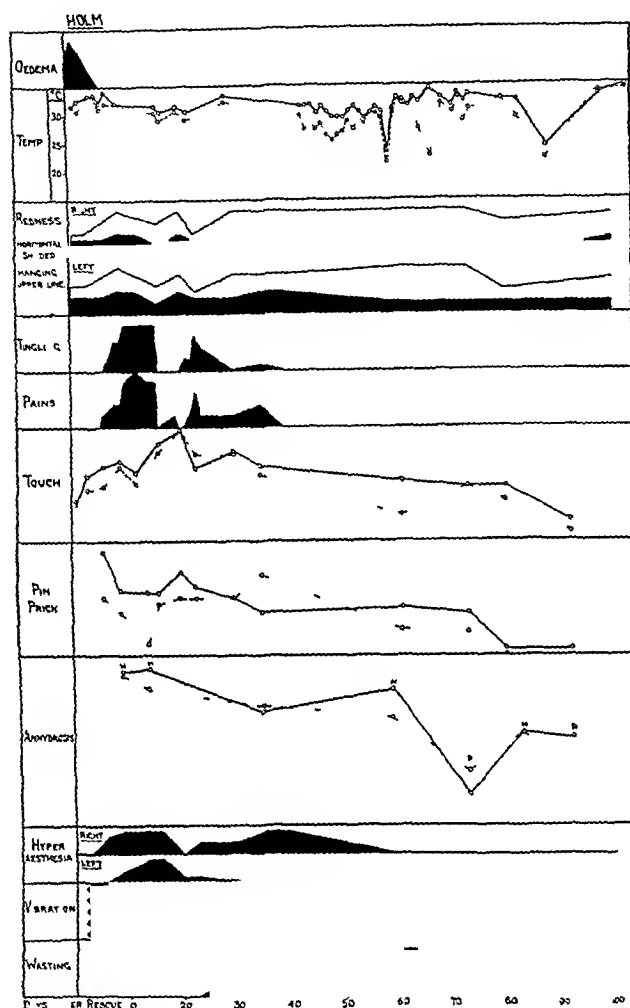


FIG 12.—Progress chart of a typical case of immersion foot. Severity Grade C V. Shows duration of swelling, redness, tingling, pains, and hyperaesthesia. The temperature of the great toes and the extent of sensory loss and anhidrosis are also represented. Right foot, continuous line, Left foot, dotted line. Same case as Figs 16-18 and 20.

In the early hyperaemic stage movements of the ankle and toes are hampered by swelling. As oedema subsides, weakness and wasting of the intrinsic muscles of the foot become apparent and the toes become clawed. The wasted muscles exhibit diminished electrical excitability. When patients begin to walk, they have a flat-footed springless gait. Wasting of the muscles may persist for a long time, even after there is recovery of sensation and evidence that the muscles are re-innervated.

At first there is an area of anhidrosis corresponding to the zone of hyperaemia. The hot, moist, red foot mentioned by Critchley (1943) appears to be unusual. Later sweating, like sensation, recovers rapidly, and

tests of thermo-regulatory sweating (Guttman, 1940) show that anhidrosis corresponds with analgesia (Fig 11).

Areas that are to become gangrenous fail to warm, remain white or blue, blister extensively at first, and later become shrivelled and black. In the early stages it is difficult to be certain of areas that are to become gangrenous. Often the necrosis is only superficial and later the dead tissue is shed, leaving pink healthy skin or at the worst shallow ulcers. In this way complete thumb-like casts of the digits including the nails may be obtained. In practically all cases the superficial epidermis becomes thick, hard, yellowish-brown in colour and desquamates completely within the first few weeks. Extensive gangrene is rare and even when an apparent line of demarcation encircles the limb or the base of a digit, it is by no means certain that all tissues distal to this are gangrenous.

General symptoms during the hyperaemic stage include occasional transient albuminuria, slight tachycardia, mild pyrexia, sometimes for several weeks, and minor variations in the leucocyte picture. Respiratory infections and alimentary disorders are rare. A few days after rescue, one patient had severe melana and later developed symptoms suggestive of a duodenal ulcer. He had hyperchlorhydria, but an ulcer was not found on radiological examination. A similar case has been described by Goldstone and Corbett (1944).

The duration of the hyperaemic stage varies from a few days to a few months according to the severity of the case (Fig 13). It is probable that even the mildest cases have a transient hyperaemia which passes unnoticed. The average duration of the hyperaemia in moderately severe cases is from 6 to 10 weeks. Towards the end of this period the hyperaemia begins to show signs of instability and the affected extremities may on occasion be found to be cool or cold (Fig 12).

**4 Post-hyperaemic Stage**—This stage may be absent, mild cases pass from the phase of warmth to normality. In the typical moderately severe case of immersion foot, transition from a hyperaemic to a post-hyperaemic stage occurs, but is never abrupt. The first indication that a change is about to occur is that the feet, previously consistently warm, are noted to be cool (Fig 12). At first there is always some precipitating factor which causes the feet to become cool (e.g., a tepid bath, walking barefoot on a cold floor, etc.), but later the feet are noted to become cold spontaneously. Once they have become cold, the feet tend to remain cold for several hours, and, even when means of accelerating warming are adopted, they regain their previously warm state very gradually (see Fig 17). For this phase, Sir Thomas Lewis has suggested the descriptive term 'algid' state. Later still the feet become permanently cold and are 'cold-sensitive'—i.e., when exposed to moderate cold they cool abnormally and return very slowly to a normal resting temperature. In some cases the feet are also heat-sensitive, after exercise or when the patient is in bed the feet become unbearably hot and the patient is forced to take active measures to cool them. This instability of temperature may not be associated with any apparent change in the appearance of the feet, in



other cases there is a marked degree of cyanosis. Colour changes on elevation and dependency may still be present but are less pronounced than in the earlier stages.

The other presenting feature of the post-hyperæmic phase is spontaneous excessive sweating. Patients complain that when walking, particularly

contractures of the toes. In feet which were initially damaged to the extent of superficial gangrene, there may be evidence suggestive of vascular occlusion, impaired pulsation in the peripheral arteries, delay in healing of ulcers formed by blisters and the removal of gangrenous tissue, and pain in the legs suggestive of intermittent claudication. Decalcification of the bones of the foot similar to post-traumatic osteoporosis is frequently seen but tends to recovery.

According to Professor Orloff, of Archangel (1943), the after-effects of immersion foot may last for many years and relapses are common. We have seen patients who were considered to have been mildly affected still complaining after three or four years. Many patients remain well while ashore but may have recurrence of symptoms when they return to sea in northern latitudes.

**IMMERSION HAND**

In at least two-thirds of patients with immersion foot the hands are also affected, usually less severely. In cases with slight degrees of immersion foot the incidence of immersion hand is about 50 per cent and severity is minimal, in severe degrees of immersion foot the incidence rises to 90 per cent and severity also increases.

The hands are seldom continuously immersed, but are nevertheless exposed to severe degrees of cold and wet. In addition, general body cooling results in strong reflex vasoconstriction in the upper limbs.

Occasionally the hands are more severely affected than the feet. One example of this type of case was seen in an airman who spent 14 hours adrift in a rubber dinghy. He was clinging to the centre rope of the dinghy and his hands were immersed as much as his feet. Another similar case has been described elsewhere (Richards, 1944).

If the hands are used actively, e.g., for rowing or baling, they are less likely to suffer damage, and if one hand is more exposed or more immobile than its fellow, it will suffer more severely. This has been noted particularly in patients who have used one hand to scoop up water or snow in order to quench their thirst. If air temperature is very low, non-immersed hands may suffer from frost-bite, immersion foot and frost-bite of the digits of the right hand were both observed in a patient who had been grasping a metal bailer.

The clinical picture of immersion hand is similar to that of immersion foot. During exposure the hands are numb, swollen, and clumsy, and survivors find difficulty in undoing buckles or caps of flasks.

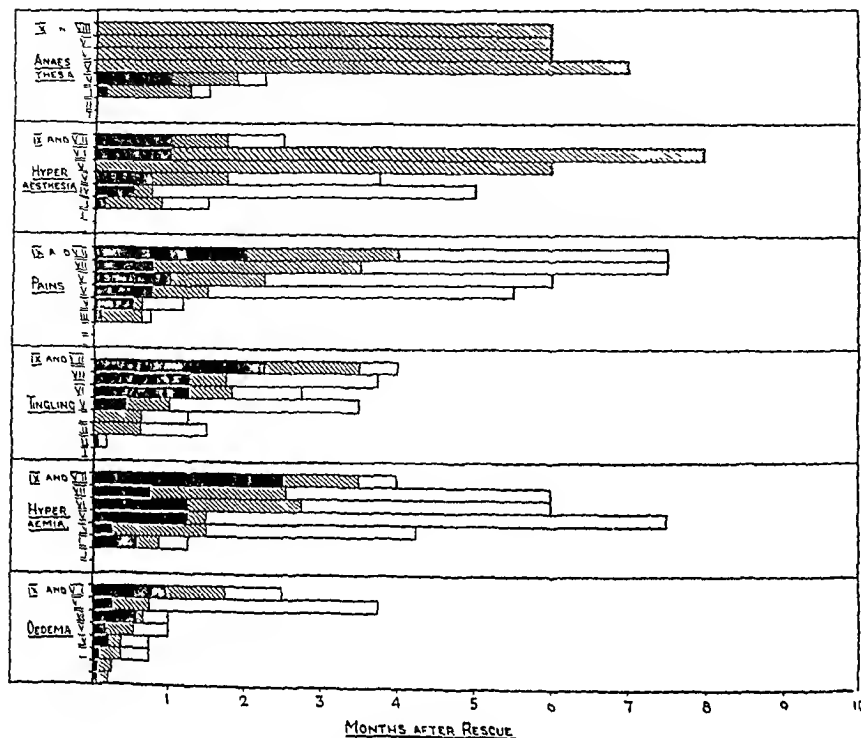


FIG. 13.—Chart to show the duration of symptoms and signs according to degree of severity. Black areas, minimum duration, Shaded areas, average duration, Unshaded areas, maximum duration.

on a warm day, their socks become soaked with perspiration and even in a cool room the cold feet may sweat excessively. Sweat rashes are not uncommon over areas where sweating is heaviest. This hyperhidrosis is similar to that observed in causalgia and other irritative nerve lesions in that it is most obvious in response to emotional or noxious stimuli, whereas over the affected area thermoregulatory sweating may be diminished. Sweating is often most pronounced at the margins of analgesic and anhidrotic areas, this is the 'marginal hyperhidrosis' described by Guttman (1940). In other cases the hyperhidrosis is associated with recovery of sensation and hyperalgesia—the 'hyperhidrosis of recovery'. Excessive sweating may be observed in relatively mild cases with little sensory loss and may be a manifestation of partial denervation or partial re-innervation of sweat glands.

Recurrent swelling of the feet, a return of tingling or shooting pain, and further crops of blisters are other complaints which are frequently made by patients in the post-hyperæmic phase. Sensation recovers gradually, wasting of the intrinsic muscles tends to disappear, and movements of the toes improve. In severe cases there may be permanent

After rescue, the hands become hot and throbbing and intense paræsthesiæ are felt in the finger-tips. Swelling is less than in the feet, but when it subsides, wasting of the intrinsic muscles is very prominent, the appearance presented being similar to that of progressive muscular atrophy. There appears to be a dissociation between motor and sensory functions, as severe wasting may be present with little or no objective loss of sensation. Pain in the hands is uncommon, but tingling persists for a long time and is most prominent when the hands are exposed to cold or are warming. Objective sensory findings as a rule are confined to hypæsthesia and hypalgæsia of the finger-tips. The skin assumes a dirty-yellow colour and desquamates, leaving healthy pink skin. Even in mild cases, cold sensitivity is common, and in more severe cases attacks of the Raynaud phenomenon have been observed. Hyperhidrosis is also prominent in the hands, but subsides more rapidly than in the feet. In the late stages, although the hands may appear normal, patients complain that as soon as they are exposed to cold, their hands become stiff, numb, and weak. Critchley (1943) has described permanent deformity of the fingers due to contracture of the flexor tendons and atrophy of subcutaneous tissue.

### SKIN TEMPERATURE OBSERVATIONS

It is not possible to make readings during the period of exposure. From experiments on volunteers it is known that when a limb is immersed in

within a few hours reached full vasodilatation level ( $35-36^{\circ}\text{C}$ ).

Once the hyperæmic stage is fully developed, the hand or foot, except for gangrenous areas, is warmer

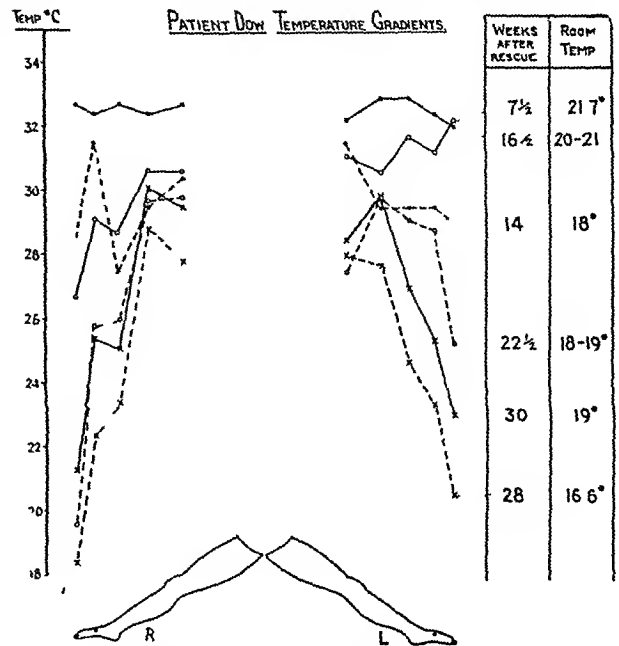


FIG 15—Skin temperature gradients in a case of immersion foot. Note initial high temperature of the feet with a return to the normal gradient at 28-30 weeks after rescue. Same case as Fig 14.

than the upper arm or thigh (Fig 15)—that is, the normal vasoconstrictor gradient is abolished. There may be no further rise in the skin temperature of



FIG 14—Gangrene of the toes in a case of immersion foot. This case was regarded as only of moderate severity (Grade C V), but the feet were heated after rescue.

cold water the temperature of the digits falls rapidly to within  $1^{\circ}$  to  $2^{\circ}$  of the water temperature (Wolf and Hardy, 1941, Lewis, 1942, Holling, 1943). The earliest records of skin temperature have been made 9-12 hours after rescue (Richards, 1944). At this time the digits were already warm and

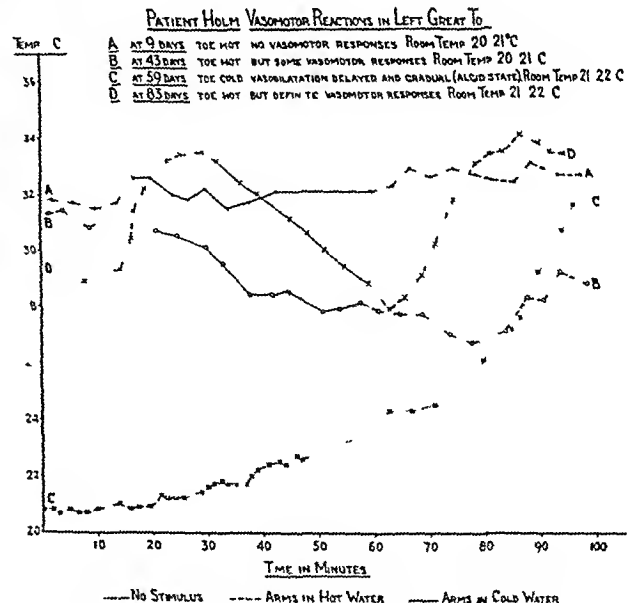


FIG 16—Vasomotor reactions in a moderately severe case of immersion foot. Same case as Figs 12, 17, 18, and 20.

the distal parts even after nerve-block. The toes remain hot and reflex vasomotor activity in response to immersion of the arms either in hot or in cold water is absent (Fig 16, A). At a later stage slight



cooling of the extremities becomes apparent, but there is still evidence of diminished vasoconstrictor tone in the feet, so that the toes remain warmer than normal (*Fig 15*). Reflex vasomotor activity may now be demonstrated in the digits, but the response is gradual (*Fig 16, B, D*). About this time, the vasomotor state becomes unstable so that variations in skin temperature from day to day are considerable (see *Fig 12*).

In the post-hyperæmic stage, when a normal vasoconstrictor gradient has been restored, and the feet are almost habitually cool, many degrees of reflex vasomotor activity may be observed. Mild cases may show normal vasomotor reactions within a few weeks of rescue. Other cases may show a conspicuous delay before normal vasodilatation occurs (*Fig 17, left foot*). In more severe cases,

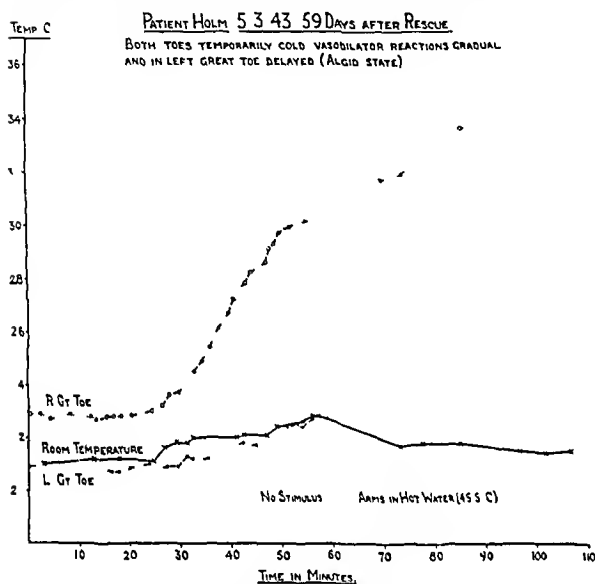


FIG 17—Chart to show delayed vasodilatation in the left great toe. The feet were temporarily cold as a result of standing on a cold floor. Vasodilatation is gradual in both great toes and delayed in the left (algid state). Same case as *Figs 12, 16-18 and 20*.

there is complete failure of reflex vasodilatation. It is to be noted that this failure may occur even when the initial temperature of the feet is relatively high (24–26°C). This is apparently not due to any obstruction in the cutaneous blood-vessels, since the local injection of histamine causes a conspicuous rise in temperature (Richards, 1944).

Interesting observations have been obtained by recording skin temperature during periods of fan-cooling used as a therapeutic measure (Ungley, 1943, a). These observations were made more than 2 weeks after rescue in the hyperæmic stage in cases of moderate severity. Cooling of the toes to 24–25°C was followed by a fairly rapid, but not abrupt, return of skin temperature to the previous high level (*Fig 18*). After further cooling to 17°C, subsequent warming of the toes was slow (Ungley, 1943, a). Once the hyperæmic stage has become unstable, fan-cooling may be followed by a period of prolonged coldness. These results must be compared with those obtained in normal feet made artificially

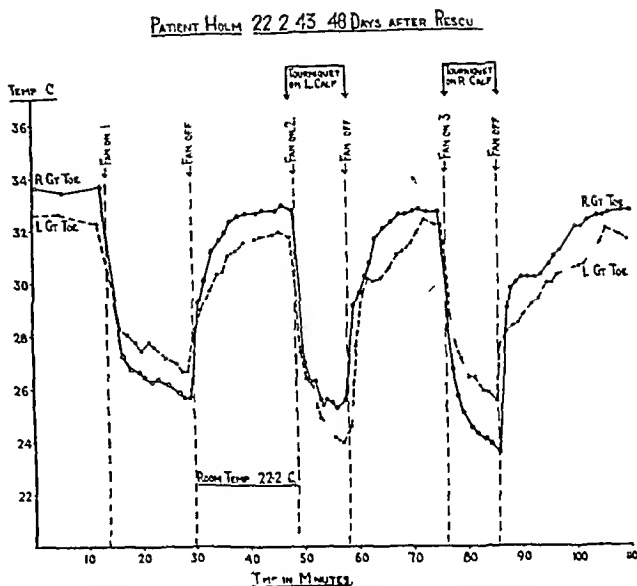


FIG 18—To show the effect of fan cooling the feet in the hyperæmic stage of immersion foot. Same case as *Figs 12, 16, 17, and 20*.

hyperæmic by the administration of a spinal anaesthetic (*Fig 19*). In the latter a return to the high resting temperature takes place immediately the fan is switched off.

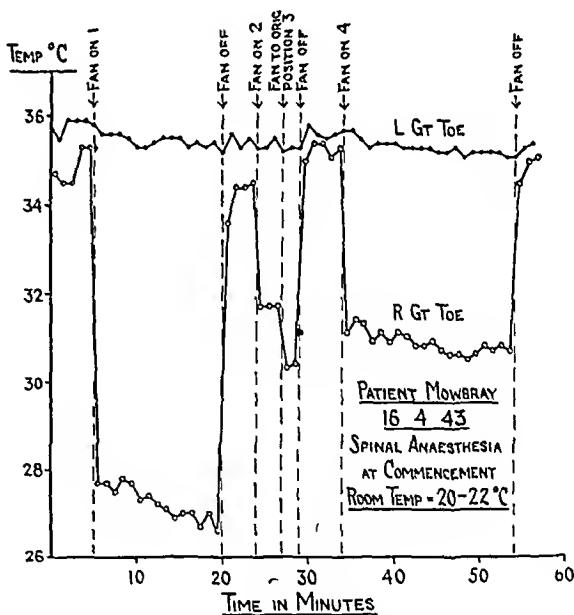


FIG 19—To show the effect of fan cooling normal feet after the administration of a spinal anaesthetic, cf *Fig 18*.

Sensitization of the digital blood-vessels to circulating adrenaline is also present in the hyperæmic stage of immersion foot. This is demonstrated in *Fig 20*. The significance of these observations will be considered later.

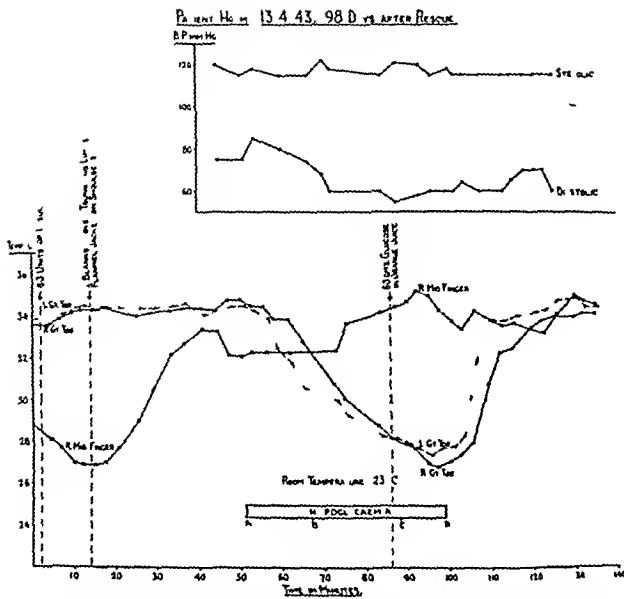


FIG 20—To show the effect of insulin hypoglycemia in the hyperæmic stage of immersion foot. Note pronounced fall in temperature of both toes with a slight rise in finger temperature during the period of hypoglycemia. Same case as Figs 12, 16-18

### GRADES OF SEVERITY

Webster et al (1942) divided their cases into four groups according to the degree of œdema, blistering, ecchymosis, etc., the most severe cases had massive extravasation of blood and incipient gangrene. In our experience the most significant factor in prognosis is the amount of damage to peripheral nerves. A useful criterion is the extent of the loss of sensation to cotton-wool touches at the end of the first week after rescue, and cases have been subdivided into nine groups on this basis. The extent of the anæsthesia and the correlation between this and the severity of other symptoms in each group is demonstrated in Fig 21\*. In Groups III and IV nerve damage is designated 'reversible' because symptoms and signs disappear within 4 to 9 weeks—a period which is too short to permit of any extensive regrowth of nerve-fibres. In Groups V to IX, on the other hand, recovery is slow and is considered to take place by regrowth of axons, nerve damage in this group is therefore regarded as 'irreversible' or 'degenerative'. On this latter basis a somewhat broader classification appears justifiable, viz—

*Grade A Minimal Cases without Interference (or with transient interference) with Nerve Function*—In this

group of cases the feet are swollen for a few days, and there may be transient tingling. Both features subside within a week. In a few instances pains develop in the second week. Late sequels are rare, but there may be some cold sensitivity.

*Grade B Mild Cases with Reversible Nerve Damage*—Anæsthesia is confined to parts of the plantar surfaces of the feet and the tips of the toes and disappears in 4 to 9 weeks. In the great toes, vibration sense is lost in about 25 per cent of cases, but position sense is not affected. Weakness of the intrinsic muscles of the feet may be present for a few weeks, but there is seldom any wasting or impairment of electrical excitability. Œdema lasts 1 to 3 weeks, hyperæmia 3 to 7 weeks, tingling pain and hyperæsthesia last 2 to 4 weeks. Blisters and gangrene do not appear in this group. Sooner or later about half the patients complain of excessive sweating of the feet, and in a similar number the parts are cold-sensitive. The stay in hospital is 4 to 8 weeks and men return to full duty ashore or afloat within 3 to 4 months of rescue.

*Grade C Moderately Severe Cases with Irreversible (Degenerative) Nerve Lesions*—In this group the cases have complete anæsthesia of the plantar surfaces of the feet, the dorsum and sides of the feet are involved to an extent varying from the distal segments of the toes to a level just distal to the ankle-joints. Vibration sense is nearly always absent in the great toes and position sense much impaired. Wasting of the intrinsic muscles with loss of power and impaired electrical reactions are

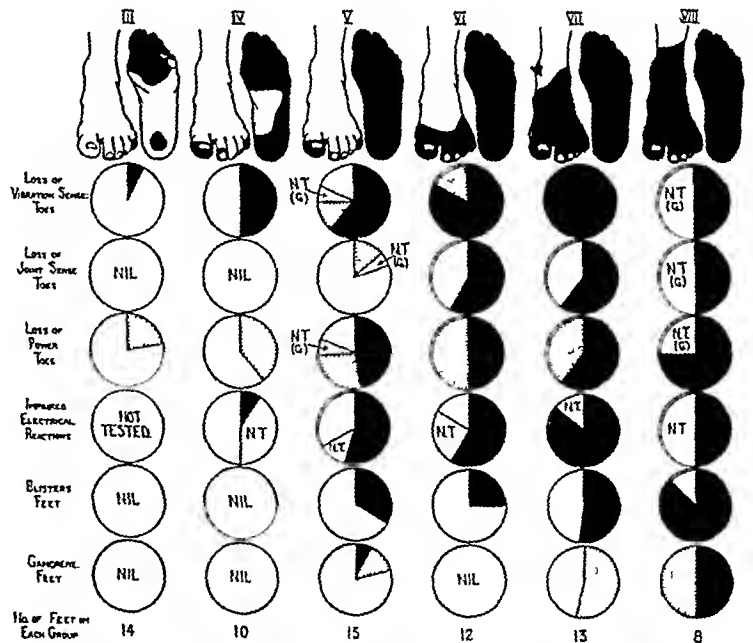


FIG 21—Chart showing the classification of cases of immersion foot according to the extent of anæsthesia at 7-10 days after rescue. Shows how extent of anæsthesia is closely correlated with severity in other respects. In the circles the black areas indicate the proportion of feet affected in each group, stippled areas refer to partial defects or to superficial as opposed to deep gangrene. Feet not tested are represented by unshaded areas marked NT, or, if gangrenous, NT (G). Grade IX has been omitted as the extent of gangrene was such as to prevent complete testing.

\* To obtain a quantitative estimate of anæsthesia, the following method was adopted. The foot and leg were divided into a number of arbitrary geometric areas. Sensation to cotton-wool touches was tested in each of these areas, and the number of areas from which a response was not obtained was taken as an index of anæsthesia.

present. Œdema lasts 2 to 3 weeks, tingling 4 to 8 weeks, stabbing pains and hyperæmia last 5 to 14 weeks, and hyperæsthesia lasts 6 to 8 weeks or

longer in severe cases. Blisters develop in about half the cases and superficial gangrene may occur. Sensory loss and motor disorders persist for many months, at 6 months the extent of the anaesthesia is still considerable. Later hyperhidrosis and cold sensitivity develop in rather more than half the cases. Recurrence of pains, tingling, and swelling is common. The stay in hospital for patients in this group is 9 weeks to 6 months. In time more than half the patients recover sufficiently to return to full duty and only about one-quarter require to be invalided from the service.

**Grade D Severe Cases with Irreversible (Degenerative) Nerve Lesions and Gangrene**—In this group anaesthesia covers the whole foot to above the level of the malleoli. Such toes as are available for testing show loss of vibration and position sense. The small muscles of the feet are wasted and paralysed. Oedema lasts from 3 to 7 weeks, tingling, pains and hyperaemia last 3 to 4 months. Blisters appear on the feet and legs and gangrene invariably develops, usually resulting in the loss of digits. In the later stages gangrene is complicated by sepsis and amputation may be necessary. Most patients in this group spend at least 6 months in hospital, and even at the end of that period are severely disabled. Very few become fit even for the lightest of service duties.

### AETIOLOGICAL FACTORS

The essential cause of immersion foot is prolonged exposure of the limbs to cold insufficient to freeze the tissues. Whereas sea water freezes at  $-1.9^{\circ}\text{C}$ , tissues do not freeze above  $-2.5^{\circ}\text{C}$ , so that parts continuously immersed cannot be frost-bitten. The sea temperatures affecting our series of cases probably ranged from  $-1.9^{\circ}\text{C}$  to  $15^{\circ}\text{C}$ . These figures are derived either from readings at

considerably shorter than 2 hours may possibly produce vascuopathy (see below).

Conditions such as malnutrition and exhaustion, which lower metabolism and general vitality, predispose to immersion foot, as to trench foot. Seasickness, dehydration, and starvation were common contributory factors in our series. Neither in Webster's cases nor in ours, however, were there signs of acute vitamin deficiency (stomatitis, haemorrhage, or visual disturbances). The possibility that oedema and nerve lesions might be due to deficiency of vitamin B<sub>1</sub> was investigated with negative results.

Many survivors have remarked that those who lost heart died more quickly or suffered more severely than their companions. The few men over 40 and under 17 seemed to die from cold sooner than those of intermediate age. Within the main group age and severity were not closely correlated. Coloured races are said to be more prone to trench foot. In Webster's series those who suffered most were Greeks, negroes, Australians, and men employed in the engine room or stokehold. In our series, however, Arab firemen suffered no more than European deckhands.

Relative immobility and continued dependency of the feet are important factors. Mechanical interference with the circulation, as from tight clothing or continued pressure from the edge of a seat, also accentuates the condition. Chilling of the upper parts of the body from wind and wet, and inadequate clothing, act by reducing peripheral circulation.

Immersion has no specific action apart from its effect in increasing the rate of heat loss, and is not an essential factor. The disorder may arise in extremities exposed to prolonged cold with no more damp than is provided by condensed perspiration.



FIG. 22.—Photographs to show the progress and end result of a severe case of immersion foot (Grade D VIII). A, 7 days after rescue, B, 5 weeks after rescue, C, 7 months after rescue.

the time, from maritime surveys, or from the atlas of Schott (1926). When there was floating ice and the spray froze as it fell inboard, the water temperature was judged to be approaching  $-1.9^{\circ}\text{C}$ . With sea temperatures of  $0^{\circ}$  to  $8^{\circ}\text{C}$ , periods as short as 22 hours and even 14 hours have been sufficient to cause severe nerve damage. Experimental immersion for 2 hours in water at  $3.9^{\circ}\text{C}$  has produced transient neurological signs including anaesthesia, which did not entirely resolve within 3 hours when the feet were warm (Holling et al., 1943). In cold so intense that sea water freezes, periods of immersion

We have seen a number of cases of so-called 'seaboot foot' in men serving in ships on North Atlantic and Arctic convoys. In some instances at least the degree of cold was not such as to have caused frost-bite and the condition has been observed with temperatures as high as  $8^{\circ}$  to  $12^{\circ}\text{C}$ . Men affected were those who remained relatively immobile on the bridge or on small gun platforms, seldom for more than 4 hours at a time. After several days, during which they had usually worn rubber seaboots continuously, the feet became red, painful, and tender. They walked as though on hot bricks.

In minimal cases a change to leather footwear was followed by recovery in 3 or 4 days. In more severe cases (Grades B and C), there were usually contributory factors such as boots which had become tight, too rapid warming of the feet, seasickness, and in one instance hæmorrhage and shock from wounds.

Other cases in which the immersion foot syndrome occurred without actual immersion include an injured airman exposed 46 hours in snow, whose hands and feet were affected (Richards, 1944), an injured airman lying 22 hours in the snow whose exposed left hand was the only extremity involved (Symonds, 1942), a bus driver whose feet suffered (Gaylor, 1942), and a deserter from the army who spent 8 days in a cold pillbox and sustained severe vasoneuropathy with gangrene of the toes (Richards, 1944, Fig 22). Such cases are included along with trench foot, seaboot foot, immersion foot, and immersion hand, under the one comprehensive term 'peripheral vasoneuropathy after chilling'.

### FROST-BITE

The distinction between immersion foot and frost-bite is important. When, as happened in some cases in the present series, the hands were frost-bitten while the feet, immersed and thereby protected from freezing, showed the typical picture of immersion foot, the clinical difference between the two conditions was striking. Several excellent descriptions of frost-bite have recently been published (Greene, 1941, Bigelow, 1942, Davis et al, 1943), and it is outwith the scope of the present paper to consider this condition in detail. In frost-bite death of tissue is the result of freezing, and skin, being the most superficial tissue, suffers most, in immersion foot there is prolonged chilling and ischæmia, the tissues with the weakest biological resistance (nerve and muscle) suffer most severely, and even with irreversible nerve damage there may be no loss of skin.

In some cases the distinction between frost-bite and immersion foot is not clearly defined, e.g. For 20 minutes two men struggled in an icy sea off Murmansk. One of them was clinging to floating ice. After rescue they spent 10 minutes in an open boat exposed to very cold air. Both developed œdema, blisters, and signs of nerve damage in the extremities. The neuropathy was most marked in the hand which had grasped the floating ice. The short period of exposure and the intense coldness of the air suggested frost-bite, but the clinical features were those of immersion foot.

Cases of this nature are exceptional, but they suggest that the distinction between frost-bite and immersion foot may not be so clear-cut as has been believed heretofore.

### ŒDEMA OF THE LIMBS IN SURVIVORS FROM SHIPWRECK IN WARM WATERS

Even in the tropics, œdema of the feet may follow exposure in open boats. The syndrome has been described by White (1943, b), and it is probable that some of the cases described by Goldstone and Corbett (1944) belong to this group. In the present series there are two groups of survivors from shipwreck in warm waters. From a consideration of

these cases and those described by White (1943, b), it is apparent that this group does not form a simple clinical entity. A number of factors is involved including relative immobility and dependency of the feet, immersion in warm sea water, semi-starvation, dehydration, and the effects of strong sunlight. Many of the cases resemble the peripheral vasoneuropathy observed after chilling, and it is for that reason that the syndrome is mentioned here.

### MORBID ANATOMY

Pathological material obtained from the present series has been examined and reported upon by Blackwood (1944). He finds that nerve and muscle suffer most severely. The peripheral nerves undergo a process of patchy Wallerian degeneration. Changes are most marked in the distal portions of the nerves, and fibres of small calibre appear to suffer more severely than large medullated fibres. Later the findings are similar to those observed in any nerve which is regenerating after injury. Damage to muscle occurs during exposure. The muscles become fragile and are apt to tear. This may result in intramuscular hæmorrhages and scar formation. In the early stages the muscle-fibres show changes similar to those of Zenker's hyaline necrosis, later the changes in the muscles are those of denervation and progressive re-innervation. In bone there is early osteoporosis followed by the deposition of new bone subperiosteally and around the Haversian canals. Histologically the peripheral arteries appear normal and changes in capillaries and veins are usually restricted to areas adjacent to gangrenous and infected tissue.

### PATHOGENESIS

Since the review of Ungley and Blackwood (1942), additional evidence bearing upon the problem of pathogenesis has appeared in papers by Critchley (1943), White (1943, a and b), Ungley (1943, b), Blackwood and Russell (1943), and Blackwood (1944). Only three main causal factors require consideration—

1. *The Direct Effect of Cold upon the Tissues*—The effect of cold upon tissues *in vitro* was extensively studied by Lake (1917 and 1942), and more recently Sir Thomas Lewis has supplemented these researches by numerous clinical observations (Lewis and Love, 1926, Lewis, 1930, 1941, and 1942). For isolated tissues there is a critical temperature level in the neighbourhood of  $-6^{\circ}\text{C}$ , at which irreversible changes, probably of a physico-chemical nature, occur, after cooling to this level recovery is impossible. Intact tissues possess the property of super-cooling, and by virtue of this may be cooled to a lower level before actual freezing occurs. In frost-bite freezing has occurred, there is a central zone of devitalized tissue surrounded by a zone in which tissue damage is minimal. Immersion foot is due to chilling of the tissues without freezing. Opinions differ as to the amount of damage that may be done by cooling to temperatures within the range ( $-19^{\circ}\text{C}$  to  $+15^{\circ}\text{C}$ ) which causes immersion foot. Indeed, chilling of limbs to similar temperatures is now being practised as a therapeutic measure in the treatment of gangrene and peripheral sepsis (Allen, 1939). The argument which is

advanced by those who believe that the effects of cold of this degree are *per se* harmless to the tissues, rests largely upon the results obtained by Lake (1917, 1942) in his tissue cultures. As the scale of temperature is descended, anabolism ceases before katabolism. In the zone between 25° and 10° C. the products of tissue katabolism accumulate. At temperatures about zero metabolism ceases and the tissues requiring neither oxygen nor nutriment cannot therefore suffer from ischaemia. These observations suggest that damage to chilled limbs occurs not while the temperature of the tissues is low, but while the temperature is falling or rising, through the zone of imbalanced metabolism between 10° and 25° C. Metabolites which accumulate during this phase are responsible for the initial intense local vasodilatation which follows, exudation results and is responsible for the neurological and nutritional lesions. It is doubtful if this hypothesis based upon observations on isolated tissues is applicable to the human limb. The pathological studies of Smith, Ritchie, and Dawson (1915), Blackwood and Russell (1943), and Blackwood (1944) suggest that direct damage to tissues occurs during the period of low temperature.

The effect of cold upon the blood-vessels is of supreme importance. Both local and general cold cause peripheral vasoconstriction, and if these are operative together, as they are under the circumstances in which immersion foot occurs, the resultant vasospasm may be severe. In the Raynaud phenomenon vasoconstriction is sufficient to cause complete vascular stasis in a digit. It is therefore justifiable to assume that in immersion foot vasoconstriction is of itself capable of cutting off the blood-supply to the chilled extremity. Unless metabolism ceases during this phase, at least a partial ischaemia must occur.

Thrombosis need not be invoked. In experiments upon general hypothermia, Talbott (1941) found that although for many hours peripheral pulses might be impalpable and blood-pressure unrecordable, yet thrombosis did not occur. This is presumably true of immersion foot. There is no evidence that organic arterial obstruction is a factor in the causation of the syndrome. The work of Greene (1943) and certain Scandinavian workers (Bigelow, 1942) has shown that even in true frost-bite, thrombosis does not occur, although the lumina of the vessels may become silted up with masses of red blood-cells. In pathological material obtained after chilling, there is no organic obstruction of main blood-vessels. The clinical and pathological evidence is therefore in favour of the hypothesis that during exposure and in the pre-hyperaemic stage intense vasoconstriction is the predominant feature.

2 *The Effect of Ischaemia*—The clinical results of ischaemia as seen in conditions such as traumatic arterial spasm and tourniquet paralyses are in many respects similar to those of immersion foot. The extremity which has its blood-supply cut off or seriously reduced for several hours by spasm of the main artery or the prolonged application of a tourniquet, is probably placed in a position somewhat analogous to that of an extremity exposed to cold. In the latter, the deprivation of blood-supply is less

acute and an additional effect of cold will be to mitigate or delay changes in the tissues by reducing metabolism. The reactive hyperaemia which follows a period of circulatory arrest has its counterpart in the early hyperaemic stage of immersion foot. The sensory findings in cases of immersion foot are very similar to those recently described by Parkes (1944) in cases of ischaemia. Only the changes in the muscles (Blackwood, 1944) may be said to differ strikingly from the characteristic infarction which is seen in muscles deprived of their blood-supply.

3 *The Effect of Exudation*—The hypothesis that the symptoms of immersion foot are the result of pressure from the excessive exudation which accompanies the hyperaemia lacks support. There is no other clinical condition in which unrestricted swelling of a limb causes vascular and neurological symptoms comparable to those of immersion foot.

We therefore advance the hypothesis that immersion foot is a peripheral vasoneuropathy resulting from a combination of chilling and partial ischaemia. The most prominent and interesting feature of the syndrome is the vascular disturbance, and it is therefore of importance to consider this further.

1 *Hyperaemic Stage*—If it is assumed that vasoconstriction is present during exposure and the prehyperaemic stage, then the transition to the hyperaemic stage will occur when the warmth of the body and the proximal portions of the limbs overcome this vasoconstriction. The excessive vasodilatation which is present in the hyperaemic stage may be due to three factors: inflammation with the release of vasodilator metabolites, local damage to vessels, and vasoconstrictor paralysis.

Sir Thomas Lewis (1941) has demonstrated that an aseptic type of inflammation occurs in tissues exposed to cold. The vasodilatation which succeeds a brief period of exposure to cold has been shown by Lewis (1930) to be the result of an axon reflex producing a relatively stable vasodilator substance similar to histamine. A similar vasodilator substance is also produced in ischaemic tissues and is responsible for the phenomenon of reactive hyperaemia (Lewis, 1927). An accumulation of vasodilator metabolites may well boost the initial hyperaemia, but once an active circulation is established, these will be rapidly washed away from the tissues. Unless substances continue to be released, they cannot be the cause of a vasodilatation, the duration of which is measured in weeks rather than days. Bacterial infection does not play a part in the early stages of the hyperaemic phase, but may be a factor in the presence of blisters, ulcers, and gangrene.

Blood-vessels may be damaged either directly by cold or from ischaemia. There is no histological evidence of gross damage to arteries and arterioles (Blackwood, 1944). The remarkable changes in skin colour on elevation and dependency of the feet and the presence of petechiae and swelling indicate that the walls of the minute cutaneous vessels are damaged. Some of this damage probably occurs during exposure, and is accentuated by the sudden increase in blood-flow during the onset of the hyperaemia.

In both experimental and human biopsy material severe damage to peripheral nerves is present (Blackwood and Russell, 1943, Blackwood, 1944). In the main nerves of the foot the majority of the fibres are degenerated and any which escape are of large calibre. Sympathetic vasoconstrictor fibres are of small calibre, and although affected late in ischæmia, are relatively susceptible to cold (Bickford, 1939), and are therefore unlikely to escape. The blood-vessels of the foot are thus subjected to a form of post-ganglionic sympathectomy. A week after exposure skin-temperature gradients from affected limbs are very similar to those from sympathectomized limbs. The standard sympathectomy performed for the lower limb is predominantly preganglionic, and it is unwise to strain this comparison. Complete division of the sciatic nerve results in the interruption of all post-ganglionic sympathetic fibres to the foot (except for a few in the long saphenous nerve). Such lesions produce a complete vasomotor paralysis in the toes, resulting in a foot initially warm and pale, but later varying in temperature with that of the environment. The duration of the initial hyperæmia is of the order of 21 days, and there is not the wide fluctuation in the duration of the hyperæmia that is seen in cases of immersion foot. After the initial intense hyperæmia, moderately severe cases of immersion foot show a partial recovery of vasoconstrictor tone and a small rise or fall of temperature in response to immersion of the arms in hot or cold water. The vasomotor disturbances of this group are similar to those described by Wilkins and Kolb (1941) in cases of polyneuritis, and to those found by Richards (1944) in cases of incomplete division of the sciatic nerve.

These findings suggest that vasoconstrictor paralysis is an important factor in causing the continued hyperæmia of immersion foot. This hypothesis is further supported by the demonstration that the digital vessels are abnormally sensitive to circulating adrenaline and to the effects of local cold, both these phenomena are known sequelæ of post-ganglionic sympathectomy (Grant, 1935-6, White and Smithwick, 1942).

*2 Post-hyperæmic Stage with Cold Sensitivity* — The cold sensitivity of the late stages of immersion foot cannot be entirely explained by the recovery of tone in vessels remaining denervated. Contributing factors are disuse (the increased muscle blood-flow which accompanies even slight exercise and warms the overlying skin will not occur in denervated muscles), and the absence in denervated skin of the axon-reflex (Lewis, 1927 and 1930) which is responsible for the local vasodilator reaction to cold and normally comes into play at temperatures below 15-18° C, these and other factors in the causation of coldness following peripheral nerve lesions are discussed by Richards (1943) and Doupe (1943).

There remains the difficulty that coldness and cold-sensitivity persist in some cases of immersion foot where observations on sensation and sweating indicate that a large measure of nerve regeneration has occurred. Here three further mechanisms may be involved —

1 Exposure to severe cold, whether dry cold or wet cold, sensitizes the peripheral blood-vessels so

that thereafter they are more susceptible to the effects of milder degrees of cold. The mechanism is obscure, but is presumably similar to that responsible for the Raynaud phenomenon. In the latter the digital arteries are sensitized either as the result of repeated exposure to mild degrees of cold, or because of some inherent 'local fault' in the arteries themselves.

2 Intense vasoconstriction of sympathetic origin might account for persistent coldness of the extremities and failure of reflex vasodilatation. The presence of excess sweating is suggestive of increased sympathetic activity. Reflex vasodilatation, however, fails to occur even when the initial temperature of the feet is fairly high (Gaylor, 1943).

Failure of reflex vasodilatation or a gradual rise in temperature might be the result of occlusion of the main arteries. This can be excluded in the majority of cases because the peripheral pulses are of good volume. Patency of the arteries of the foot in one case had been demonstrated by arteriography. In histological material, Blackwood (1944) has failed to find occlusion of arteries except in areas immediately proximal to gangrenous tissue. The possibility that smaller vessels of the order of arterioles are occluded requires further consideration. In biopsies from cases of immersion foot four months after exposure, White and Warren (1944) found extensive fibrosis of subcutaneous tissue and superficial muscle. They state "The arterioles and venules show partial to almost complete occlusion as a result of a great increase of the fibrous tissue in their walls. The arteries and veins of larger calibre show the same type of fibrous thickening of the wall, but with a lesser degree of occlusion of the lumen." If these findings are confirmed, they would be quite sufficient to account for a failure of reflex vasodilatation. It may further be assumed that the constriction of nerve-endings by interstitial tissue and collagen, which White and Warren suggest is the cause of the late pain in immersion foot, will affect vasoconstrictor nerves, thus interfering with normal vascular responses. On the other hand, after failure of reflex vasodilatation there may be an excellent vasodilatation in response to the local injection of histamine. According to Lewis (1927), this response is the result of an arteriolar dilatation.

3 An alternative explanation has been put forward by one of us (Ungley, 1943, b). Cold sensitivity is observed at a time when observations on sensation and sweating suggest that a certain amount of regeneration of damaged nerve-fibres has taken place. Partially re-innervated cutaneous blood-vessels may behave like partially denervated vessels, and react excessively to chemical vasoconstrictors (adrenaline, sympathin) circulating in the blood-stream or produced locally.

In conclusion, it may be stated that the available evidence favours the hypothesis that the initial hyperæmia of immersion foot is the result of the release in chilled and partially ischæmic tissues of relatively stable vasodilator substances, and that once the effect of these has subsided the hyperæmia is maintained because there is a paralysis of peripheral vasoconstrictor nerve-fibres. The late vascular phenomena are more difficult to explain, but it is assumed that they are the result of denervation and



the subsequent re-innervation of peripheral blood-vessels, which may also acquire a sensitivity to cold analogous to that seen in the Raynaud phenomenon

## PREVENTION AND TREATMENT

Official instructions (*M R C War Memorandum No 8*) have been issued regarding the procedure to be adopted by men who abandon ship in latitudes where immersion foot is liable to occur. There is no need to repeat these here, but a word may be said regarding footwear and the advisability of rubbing the feet with oil. Footwear affords some protection during short exposure, but over long periods boots may constrict swelling feet and impair circulation. A booted foot often suffers more damage than a bare foot. Rubber boots are no better than leather ones, even if not filled with water, the feet soon become wet from condensed perspiration. If possible, wet socks should be changed for dry ones, and, as soon as boots begin to feel tight, they should be removed and not replaced. Lewis and Love (1926) have shown that greasy skin supercools to a greater degree than dry skin. For this reason, and because of a traditional belief in the efficacy of fats as insulators, rubbing the exposed limb with any available oily substance has been advocated as a prophylactic measure. In the early stages of exposure this procedure is harmless and may help the peripheral circulation, but once the tissues become oedematous and friable, even gentle rubbing may be harmful. The wearing of stockings impregnated with vaseline is probably advantageous.

In discussing the treatment of immersion foot, confusion has arisen because methods which are of value in one stage have been wrongly employed in another. Therefore it is advisable to consider the treatment for each stage separately.

**Pre-hyperæmic Stage**—When rescued, the survivor must be carried, he must not be allowed to walk on damaged feet. Whether the extremities are chilled or actually frost-bitten may not be evident at once, but the principles of treatment are in any case the same at this stage. The first step is to warm the patient while protecting the affected extremities from direct heat. Stripped of wet clothing, his body is wrapped in blankets, leaving the affected limbs uncovered. He may be given hot drinks, but not left near a fire. Hot bottles may be placed near the trunk.

The feet are raised on pillows, exposed to the air, and kept dry. Massage is contra-indicated. Sulphanilamide powder may be applied to blisters and abrasions. Acriflavine is often used, but it stains the skin and obscures colour changes which should be observed.

Should the chilled limbs be warmed, cooled, or left exposed to room temperature? The fact that warmth greater than that of the human body is harmful to frozen or chilled limbs has been known for centuries. Clinical and animal experimental observations amply confirm this traditional belief.

According to some workers even gentle warmth is contra-indicated, because it increases exudation which may be in itself harmful (Smith, Ritchie, and Dawson, 1915, Lewis and Love, 1926, Lake, 1917 and 1942, Greene, 1942). In immersion foot individual variations have been too great to permit

judgement of the end-results of gentle warming on rescue. In animal experiments Blackwood and Russell (1943) found that gentle warming (water at 28° C and incubation at 37° C) increased the initial tissue reaction but made no difference to histological findings a month later. Brahdy (1935) did not find that very slow thawing was important: many men with apparently severe frost-bite went into warm rooms without bad effect. Certain Russian workers (Girgolv at al, 1944) have discarded the old method of gradual warming (rubbing with snow, etc.) of frozen tissues and recommend instead rapid warming without overheating.

Greene (1942) considers that the treatment of frost-bite and of "mere chilling"—trench foot and immersion foot—should be identical, and that from the beginning the parts should be kept cold, in the region of 2° to 5° C. He argues that temperatures in this region are optimal for the survival of isolated tissues in culture and of ischæmic limbs, and that even gentle warming dangerously increases the metabolism of ischæmic tissues, increases exudation, and encourages the growth of bacteria. He reasons that once the patient is warm and at rest in bed, vasoconstriction will be slight or absent. It is true that the change of environment brings about a reduction or cessation of vasoconstrictor stimuli initiated reflexly or through the circulation of adrenaline in response to cold and emotional stress. It must be remembered, however, that cold has a powerful local effect, arteries which are in spasm from the direct action of cold upon them are not likely to relax until they themselves are warmed. Thus keeping the extremities cold may have the unfortunate effect of prolonging the stage of vasospasm and ischæmia. Lewis (1942) has shown that temperatures below 15° C are harmful to tissues.

The treatment advocated by Greene has been tried in high altitude frost-bite, Davis et al (1943) treated a series of patients by keeping the parts at approximately 2° to 5° C for 24 to 48 hours after the injury had been sustained. Although swelling and blistering were less, the end-results were rather worse than when the hands were allowed to warm up naturally to room temperature.

Until we have more evidence as to the relative merits of methods so at variance as cooling to 2°–5° C on the one hand and rapid warming to 37° C on the other, we advise an intermediate course. The degree of warmth applied should be no greater than that needed to permit relaxation of the arteries: exposure of the extremities to a cool atmosphere (18° to 22° C) appears to be a logical and, in our experience, a satisfactory method. The feet are protected by a cradle beneath which is placed a bath thermometer. The environmental temperature in relation to the feet may be adjusted by altering the room temperature, or, if this is too low, by covering the cradle with blankets and allowing warm air from beneath the bedclothes to enter at the proximal end.

Moderate warmth, in still air, will take a long time to penetrate severely chilled extremities. In cases treated by one of us (G D C.) aboard a destroyer, feet exposed to air at 12° to 15° C became hyperæmic within five hours, but sometimes feet remain cold as long as two days.

Interruption of the sympathetic outflow by operation or infiltration has been recommended in the treatment of trench foot and frost-bite by certain continental observers, but the findings of Lake (1917, 1942) and Greene (1942) suggest that the procedure is valueless and even harmful at this stage. Davis et al (1943), however, claim that in high-altitude frost-bite blocking of the sympathetic trunk will effect dilatation of the peripheral capillary bed, provided that there has not been permanent anatomical injury to the capillary wall or thrombosis at the arteriolar capillary junctions. They found the following drugs did not release vasoconstriction: amyl nitrite, nitroglycerin, alcohol, aspirin, nicotinic acid, mecholyl. It must be emphasized that any efforts to hasten the release of vasoconstriction, whether by body warming, local warmth, sympathetic infiltration, or drugs, may do harm unless steps are taken to control the degree of vasodilatation when it occurs.

To sum up. In the pre-hyperæmic stage the patient's body should be warmed while the affected extremities are elevated and kept cool (18–22° C). At present there is insufficient evidence to enable a categorical statement to be made regarding the therapeutic value of cold or the employment of measures destined to cause peripheral vasodilatation.

**Hyperæmic Stage.**—To limit the excessive exudation set up by a too rapid return of circulation, several measures have been suggested. In animals, Lake (1917, 1942) found that tying the femoral artery or injecting cocaine and adrenaline, diminished exudation and tissue damage dependent thereon. For frost-bite in man, Lewis (1941) recommends intermittent compression of arteries to allow blood to return little by little to the limb, which in the meantime is kept cool. White (1943, a) suggests that compression dressings might be useful. Treatment by cooling alone, as described by Webster et al (1942) is often sufficient, and should begin as soon as vasodilatation develops.

Recent experimental evidence (Safford and Nathanson, 1944) indicates that the optimum cutaneous temperature for prolonged therapeutic cooling is 70° F (21° C), and that this temperature may be maintained for hours or even days if need be.

When hyperæmia is intense even ice-bags do not reduce the skin temperature below 80° F (26.6° C). Nevertheless, pain is relieved and within four hours the patients are comfortable, œdema usually subsides rapidly and blisters resorb. Too early removal of the ice-bags is followed by increasing œdema and even by extravasation of blood. Details of the method are given by White (1943, a). Instead of ice-bags, some form of cooling cabinet may be used (Webster et al, 1942; Greene, 1942; Bigelow and Lanyon, 1944; Eve, 1944).

In milder cases or when hyperæmia has become less intense, it will be sufficient to expose the feet to a current of air from a fan in a cool room, 15° to 18° C. For fan cooling to be effective, the greater the degree of hyperæmia, the lower must be the room temperature. If slightly greater cooling is desired, water may be sprayed through the fan with an atomizer. The speed and distance of the

fan can be adjusted to maintain skin temperatures of 23° to 26° C, in practice further cooling is found to cause discomfort (Ungley, 1943, a). Where a fan is not available, the patient may be nursed on his face with the feet and legs uncovered and elevated by an open window (Learmonth, 1943). In moderate cases when œdema has subsided, neither exudation nor necrosis follow interruption of cooling, and return to a higher skin temperature is not necessarily associated with an immediate return of pain and tingling. In these circumstances the fan may be used intermittently, when symptoms call for it, in the intervals the feet remain uncovered exposed to room air. The mode of action of treatment by cold requires further investigation. Webster et al (1942) suggest that by reducing metabolic requirements, cooling overcomes a relative anoxia in the hot tissues. White (1943, a) believes that anoxia of nerve-endings is responsible for the early pain in immersion foot, and that the relief afforded by cooling is a direct result of a more balanced metabolism. It has yet to be determined whether prolonged cooling will influence the rate of recovery of the nerve lesions.

Pain, if not relieved by cooling, may call for codeine or morphine. Sedation may be needed for patients with anxiety states, insomnia, and nightmares.

The diet should, of course, be plentiful and contain an abundance of protective foods. Nutritional deficiencies should be treated if present, but in our experience intensive treatment with B<sub>1</sub> and other vitamins does not influence the course of the disease.

The feet must be kept scrupulously clean. After daily cleansing with a solution of weak dettol and liquid soap, they should be dried with spirit and dusted with sulphanilamide powder. Blisters are snipped and any loose epidermis removed. The toes are separated by small pieces of gauze and the feet wrapped in a sterile towel. Since gangrene is nearly always superficial, any question of amputation should be deferred until a definite line of demarcation has formed. Minor amputations of the 'trimming' variety are usually all that are required, but occasionally severe pain will necessitate a more radical amputation than would otherwise be necessary.

**Post-hyperæmic Stage and Late Sequels.**—Patients suffering from immersion foot must rest in bed until all swelling is gone and they are able to walk without pain. White (1943, a) suggests that patients should perform Buerger's exercises for a week before being allowed up. Early walking may cause excoriation, blistering, or increased swelling. Efforts should be made to maintain the tone and bulk of denervated muscles and to prevent deformities such as flat-foot. Special boots and pads may be required. Learmonth (1943) suggests the use of arch supports until power has been restored to the small muscles of the foot.

Cold-sensitive states demand warm covering not only for the affected extremities, but for the rest of the limbs and for the trunk. Occupational therapy and exercises maintain muscular activity and lessen coldness from disuse. Smoking should be forbidden if there is a tendency to vasospasm. Hyperhidrosis can usually be countered by local measures such as



foot-baths and dusting powder,\* or by the administration of atropine

It is in this stage that sympathectomy or sympathetic infiltration may prove of value in the treatment of immersion foot. Telford (1943) reports a case in which 7 months after rescue the feet were swollen, stiff, and hyperhidrotic, with chronic painful ulcers on the stumps of the toes. After a bilateral lumbar sympathectomy, pain was relieved and the ulcers healed rapidly.

Late amputation is occasionally necessary to trim awkward stumps, to remove stiff contracted toes, or as a preliminary to fitting artificial limbs. When pains are persistent and severe, White (1943, a) suggests crushing the peripheral nerves at ankle level, the pains are said not to recur when the nerves regenerate, a process which takes about three months. Some patients claim benefit from treatment with short-wave diathermy and other forms of heat, which at this stage is not contra-indicated. Instructions to convalescents concern selection of footwear, frequent change of socks, use of dusting powder, and avoidance of excessive local heat and of cold and wet. Extremities once damaged by chilling are more than ordinarily susceptible to further damage by cold.

### SUMMARY

1 Prolonged exposure of the extremities to cold insufficient to cause tissue freezing produces a well-defined syndrome. 'Immersion foot' is one of the descriptive but inaccurate terms applied to this syndrome. The clinical features, aetiology, pathology, prevention, and treatment of immersion foot are considered in detail. A discussion on pathogenesis is also included.

2 In the natural history of a typical case of immersion foot there are four stages: the period of exposure and the pre-hyperæmic, hyperæmic, and post-hyperæmic stages.

3 During exposure and immediately after rescue the feet are cold, numb, swollen, and pulseless. Intense vasoconstriction sufficient to arrest blood-flow is believed to be the predominant factor during this phase.

4 This is followed by a period of intense hyperæmia, increased swelling, and severe pain. Hyperæmia is due to the release in chilled and ischaemic tissues of relatively stable vasodilator metabolites; pain may be the result of relative anoxia of sensory nerve-endings.

5 Within 7-10 days of rescue the intense hyperæmia and swelling subside and pain diminishes in intensity. A lesser degree of hyperæmia may persist for several weeks. Objective disturbances of sensation and sweating and muscular atrophy and paralysis now become apparent. These findings are correlated with damage to the peripheral nerves.

6 After several weeks the feet become cold-sensitive, when exposed to low temperature they cool abnormally and may remain cold for several hours. Hyperhidrosis frequently accompanies this

cold-sensitivity. The factors responsible for these phenomena are incompletely understood, several possible explanations are considered.

7 Severe cases may develop blisters and gangrene. The latter is usually superficial and massive loss of tissue is rare.

8 The hands may be affected but seldom as severely as the feet. The essential features of immersion hand are the same as those of immersion foot.

9 Prognosis depends upon severity. The extent of anaesthesia at 7-10 days has been found a useful guide to the latter, and has formed a basis of a method of classification.

10 Rapid warming of chilled tissues is condemned. Cold therapy is of value for the relief of pain in the hyperæmic stage, but should not be used in the pre-hyperæmic stage. Sympathectomy and other measures designed to increase the peripheral circulation should not be employed immediately after rescue, but may have a place in the treatment of the later cold-sensitive state.

This paper records the results of observations made during 1941 and 1942. Delay in publication has been necessary because of war-time difficulties of maintaining contact between the authors. In this respect we have received much help from Surgeon Rear-Admiral J W McNee. We wish to thank Professors R S Anken and J R Learmonth for much helpful advice during the preparation of the paper. The charts have been prepared by the technical staff of the Wilkie Surgical Research Laboratory, University of Edinburgh. During the period of the study, one of us (R L R) was in receipt of a personal grant from the Medical Research Council.

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\* Sarkisov-Serasini (1941) recommends frequent washing with soap and water, followed by dusting with a powder consisting of salicylic acid 2, alum 8, lycopodium 5, and talc 20 parts.

# THE MAJOR AMPUTATION STUMP

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## THE MAJOR AMPUTATION STUMP IN HEALTH AND DISEASE\*

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In these days of violence, in the battlefield, in the street, and in the factory, the amputation stump must come to be recognized as a normal anatomical and physiological organ. True, it is unique, in that it depends on man for its success, on the surgeon for its detail, and on the limb-maker for its effective function. But it is, at the same time, commonplace, for it is contrived from the same elements that comprise a normal limb, and obeys the same natural laws.

Overnight the patient has become the possessor of a new organ, the stump. This organ will henceforward be a part of his body, and on its perfection and health and efficiency will depend his comfort, his health, his independence, and his economic security.

In disease it is liable to the same pathological processes that occur in epiblastic and mesoblastic structures elsewhere.

We have to ensure not only that his diseased process has been adequately removed, but that he has become the possessor of a perfect stump. If, unavoidably, his stump becomes diseased, we must be familiar with the abnormalities to which it is liable, their prognosis and their treatment.

From the study of over 400 amputation stumps that have come under my care in the last four and a half years at the Ministry of Pensions' Hospital, Dunston Hill, I am of the opinion that it is possible to achieve for the patient a perfect stump in the vast majority of cases.

\* The British Orthopaedic Association's Robert Jones Gold Medal Essay, 1943

### ANATOMY

The Ideal Stump — The ideal stump (Fig 23) is a smoothly contoured and somewhat tapering

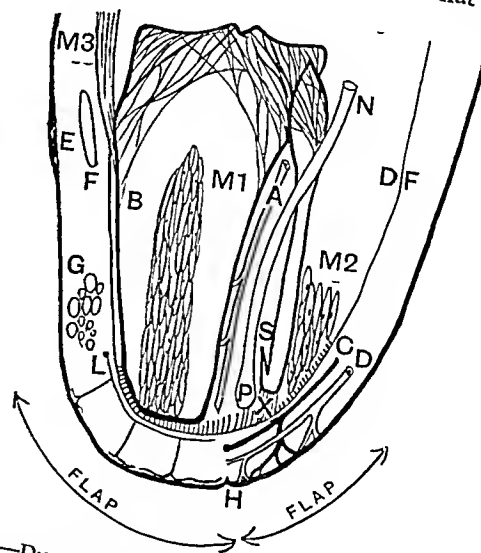


Fig 23 — Diagrammatic representation of stump anatomy. A, Artery; B, Bone; C, Cutaneous nerve-fibril; D, Cutaneous vessel; E, External scar; F, Flap; G, Subcutaneous fat; H, Hemorrhage; L, Lymphatics; M1, Muscle (Group 1); M2, Muscle (Group 2); M3, Muscle (Group 3); N, Nerve; P, Nerve end bulb; X, Internal scar; DF, Deep fascia; S, Spur.

organ, terminating in a truncated cone. It articulates with the trunk or with the proximal segment

at a joint which enjoys full range of movement and is controlled by powerful, well-balanced, and well re-educated muscles. Kelham and Perkins (1942) have recently laid down the ideal lengths for amputation in the various sites, and these cannot at present be improved upon. They are —

Below the knee,  $5\frac{1}{2}$  in from the joint line to the point of bone section

Above the knee, 10–12 in, as measured from the tip of the great trochanter

Below the elbow, 7 in measured from the tip of the olecranon

Above the elbow, 8 in from the tip of the acromion with the arm at the side



Fig 24 —An ideal below knee stump

The skin should be healthy and the flaps meet at a mobile, linear, and usually terminal scar. There should be no 'dog-ears' at the corners, no puckering, and no redundancy of the flaps and soft tissues. The flaps should, in fact, be a comfortable 'glove-fit' for the stump (Fig 24). At the sites of pressure between the artificial limb and underlying bony prominences the skin is thickened and may appear obviously cornified, and where the warmth and friction of the socket or corset of the artificial limb hinder normal skin activity, there is an increase in size and activity of both the sweat and sebaceous glands.

The subcutaneous tissue should be normal throughout, retaining its suppleness by the absence of scarring and œdema, and thus imparting free mobility to the skin of the stump. As a further result of friction, usually over bony prominences, a bursa will be found to have appeared in the subcutaneous plane. The lymphatics that drain the skin lie on the deep fascia immediately beneath the area of skin supplied, and their integrity helps considerably to maintain the health of the stump end.

The cut surfaces of all the divided structures of the limb are covered by the deep surfaces of the flaps, to which they are attached at an 'internal scar'. This is minimal in amount and density when healing has been by first intention. Where infection has accompanied healing, an extensive fibrous, or even fibro-fatty, body seals the stump end. For reasons which are discussed below, it is desirable that the deep fascia should underlie the flaps, forming a neat internal glove for the stump contents.

It is convenient to consider the muscles present in an amputation stump in three groups. The first comprises those muscles which arise in the stump and have thus lost their insertion, such as the tibialis anterior in a below-knee stump. These muscles have lost their entire function and so atrophy, though they may always be capable of a flicker of contraction. Secondly, there are the muscles which arise in the segment above, but which were inserted into a segment below, for example, the gastrocnemius in the same site. While these have lost a very large proportion of their function, they still contract and relax with movements of the joint they span, and the degree of atrophy they suffer is not so complete. The third group includes those muscles which are inserted into the stump itself. Some, like the quadriceps, again in a below-knee stump, are represented by no more than a tendon, others have their main belly lying in the stump, for instance, the deltoid in an above-elbow amputation. This group retains full function and therefore normal structure.

All divided nerves, of course, form end-bulbs, and these are attached to the internal scar by fibrous tissue whose density is in direct proportion to the infection, if any, that has accompanied healing. A densely adherent nerve end-bulb is not necessarily a painful one.

The main vessels of an amputated limb are not infrequently the site of the injury or disease that has been responsible for amputation becoming necessary.

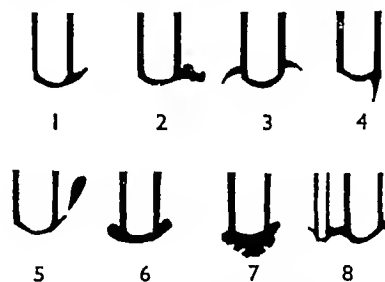


Fig 25 —Varieties of spur formation. 1, Upward-pointing, the common type. 2, Right angle, aberrant periosteal tag. 3, Umbrella, retracted periosteal cuff. 4, Downward-pointing spur. 5, Possible periosteal tag also. 6, Mushroom result of end bearing. 7, Cauliflower flower (Kelham, 1941). 8, Cross union usually the sequel of infection.

Where this is not the case, they are usually considerably reduced in calibre and may terminate in a fibrous cord which will reach up as far as the lowest patent branch.

The bones in an amputation stump are always relatively decalcified and this applies more to the distal than to the proximal one in a lower segment case. This is on account of the longitudinal thrust

which is imposed on the proximal bone by the muscles inserted into the distal one. The internal trabecular arrangement is also altered in response to new lines of stress, in the head of the tibia, for instance, the trabeculae run downwards and outwards from the articular surfaces towards the tubercle, inner tuberosity, and head of the fibula, at which points weight is transmitted, instead of more obliquely downwards as in the normal bone.

The shaft below this level may be free of trabeculation altogether and the bone end is rounded off, sealed with a thin layer of compact bone, and is almost invariably the site of a spur, which must be recognized as a normal constituent of an amputation stump (Figs 25, 26).

**The Guillotine Stump**—The guillotine stump differs from other types in that there are no flaps, but shrinkage of the scar is such that the majority of the stump end comes to be covered by normal skin and fascia, leaving a comparatively small terminal area of scar, and this may in time become completely mobile. In the upper limb it is very frequently a satisfactory stump for limb-wearing.

**The 'First-aid' Stump**—In emergencies and in the field of battle the creation of what may be termed a 'first-aid' stump has much to recommend it. This is an amputation at a considerably lower level than ideal, so that when sepsis has settled, re-amputation *secundem artem* is not embarrassed by lack of room. Apart from its site, the 'first-aid' stump presents no unusual features.

## PHYSIOLOGY

**Physiological Anatomy**—The internal economy of an amputation stump resembles very closely that of a normal limb, and calls for little comment beyond reference to the effect the altered

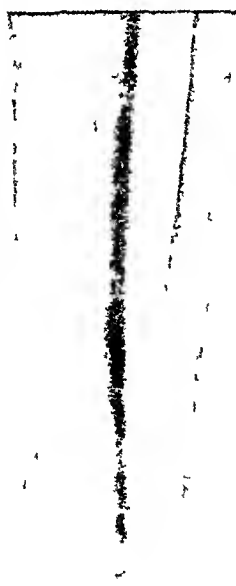


Fig 26—Type I tibial spur

demands produce. In accordance with Wolff's law, these variations in demand are met by alterations in structure, and these have already been described.

**The Physiology of Limb-wearing**—As a result of the fitting of an artificial limb an amputation stump acquires an entirely new function, one which has to be learnt in the first instance. While it is still concerned with locomotion, prehension, and sensation, the manner in which the organ carries out these functions is not only new but also varies with the site of amputation and the type of prosthesis which has been fitted. It is clearly impossible to discuss the mode of action in every different type of artificial limb, but the principal ones in use in this country to-day may be described from the aspect of function.

**The Lower Limb**—In order to understand the physiology of walking with an artificial limb, it is necessary that there should be some degree of

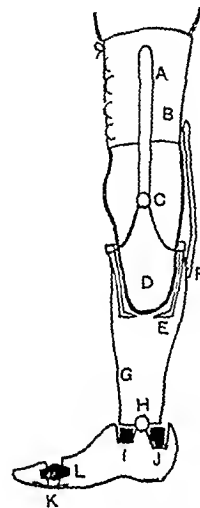


Fig 27—The below-knee limb. A, Side steel of corset, B, Corset, C, Knee-joint, D, Stump, E, Socket, F, Back check ligament, G, Shin-piece, H, Ankle-joint, I, Instep rubber, J, Heel rubber, K, Plantar hinge, L, Toe rubber. (By courtesy of Messrs J E Hanger Ltd)

familiarity with the structure of the artificial leg (Fig 27). Its main features may therefore be briefly considered. The foot and leg are similar for all types of limb excepting the modified Syme and amputations at a lower level. The leg is shaped and hollow, made usually of duralumin or wood, and at the lower end it articulates with the foot at a roller-bearing ankle-joint. Plantar- and dorsi-flexion movements are resisted by strong 'heel' and 'instep' rubbers respectively, so that if the foot is passively forced into an extreme, these rubbers tend to restore it to the mid-position. They do so by a mechanism which is doubly the reverse of muscle function, they push their own side of the joint open, whereas a muscle pulls its own side of a joint shut. The instep rubber, for instance, when compressed by passive dorsiflexion, simulates the action of the tendo Achillis by plantar flexing the foot, doing so by pushing downwards on the foot in front of the joint. There are no tarsal joints, but the metatarso-phalangeal joints are replaced by a 'toe-joint' with a plantar hinge and another rubber above it. Passive dorsiflexion at this joint compresses the rubber, which on re-expanding returns the toe part to 180°, thus copying the action of the toe flexors to some extent. The upper end of the shin articulates with the

thigh-piece in an above-knee, or with the side steels of the corset in a below-knee, limb. In the latter case, the upper end contains or forms the socket for the stump.

In the below-knee limb, it is impossible to get a single axial joint to correspond exactly with the centre of movement of the knee-joint, for the human tibia does not rotate about a constant coronal pivot. In order, therefore, to prevent friction between the socket and the stump, the former can be floated from the corset by elastic suspension. But, even better,

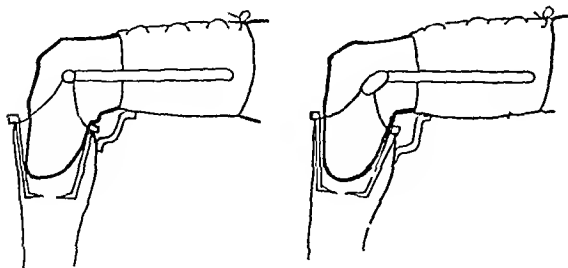


Fig. 28—The polycentric knee joint. To show the angulation in the socket that occurs in a single axial joint, and the way in which this is corrected by the polycentric knee-joint. The lower axis of the latter corresponds in extension with the axis in the monaxial limb. (By courtesy of Messrs J. E. Hanger Ltd.)

a polycentric knee-joint may be fitted which enables the locus of the tibia to be followed much more closely (Fig. 28).

In the above-knee limb (Fig. 29), the knee-joint is a coronal hinge with a small hyperextension range (about 4°), controlled by a posterior strap, or 'back check ligament'. The degree of friction in the knee can be altered by means of an adjustable brake. The upper end of the thigh-piece forms or contains the socket for the stump, fitting snugly and being flared to form a shelf for the reception of the body-weight through the tuber ischii. The limb is attached to the body by means of a pelvic band, the articulation to allow for all hip movements having three joints lying in the vertical, coronal, and sagittal planes (Fig. 30).

**Walking with the Below-knee Limb**—The position of the limb cannot be known to the wearer in the same way in which he knew the position of his leg. This knowledge was supplied by the proprioceptive impulses arising in the tendons of the foot and ankle and in the joints themselves and the stresses and strains of walking were appreciated in the same way, together with the touch and deep pressure senses of the sole. Now these functions fall to the flexors and extensors of the knee, which must learn to appreciate the flexion and extension strains of the artificial ankle, to the adductors and abductors of the hip which will now feel the lateral strains previously felt in the subtalar joint and its controlling tendons, and to the senses of touch and deep pressure in the skin of the stump at the bearing points.

Walking is commenced in most instances by carrying the amputated limb forward first. Flexion at the hip and knee are the same as in a normal leg and carry the limb with them. The knee then extends and pushes the leg portion of the limb forward with the front of the stump until the heel

is placed on the ground. The heel rubber is then compressed, which lets the forefoot down gently (cf. tibialis anterior) and then starts to re-expand, thus helping to bring the leg over the foot. The wearer is told that the heel is on the ground by the sudden pressure on the bearing points and by the

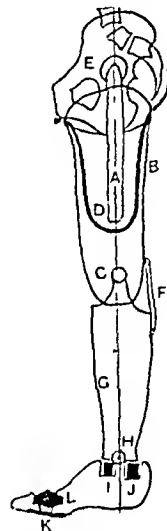


Fig. 29—The above knee limb. A, Femur, B, Socket and thigh-piece, C, Knee joint, D, Stump, E, Pelvis, F, Back check ligament, G, Shin piece, H, Ankle joint, I, Instep rubber, J, Heel rubber, K, Plantar hinge, L, Toe rubber. (Note the knee joint lies behind the line joining the tuber bearing point and the ankle joint in order to maintain locking of the knee by slight hyperextension.) (By courtesy of Messrs J. E. Hanger Ltd.)

fractional movement upwards of the socket in relation to the stump, and the corset on the thigh. As the body travels forwards, the ankle and then the toe joints become dorsiflexed, compressing the instep and toe rubbers. When the other leg begins to take the weight, these rubbers re-expand as soon as their moment about their respective joints exceeds that of the body-weight. This re-expansion plantar-flexes toe-joint and ankle at the same time, thus giving a final forward thrust off the toe and a natural-looking spring to the gait.

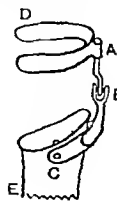


Fig. 30—The 'double-swivel' pelvic band. A, Vertical pivot (hip rotation), B, Coronal pivot (flexion and extension), C, Sagittal pivot (abduction and adduction), D, Rigid portion of pelvic band, E, Socket of artificial limb. (By courtesy of Messrs J. E. Hanger Ltd.)

**Walking with the Above-knee Limb**—Proprioception in thigh amputations is partly appreciated by variations in the pressure exerted by different parts of the socket on the corresponding parts of the stump, but is principally felt at a step later, when those pressures have been translated into alterations in tension on the tendons and muscles controlling the hip. The artificial limb has lateral rigidity, so that adduction and abduction strains on the foot are transmitted to the stump through the socket, and are appreciated by the corresponding strains at the

hip The wearer of an artificial limb will very quickly condition reflexes to control and correct these strains

In walking and standing with an above-knee limb, the most important function is the control of the knee-joint In standing the knee is kept locked by the weight of the body maintaining the position of a few degrees of hyperextension With the foot fixed by the ground, extension of the stump at the hip will obviously extend the knee A third factor is the instep rubber, which is so adjusted as to exert enough force to keep the ankle at about  $94^\circ$  If the foot is flat, the leg is thus thrust backwards at its upper end, so aiding knee locking

In walking, hip flexion throws the whole limb forwards, the leg lagging behind as a result of inertia, but the sudden cessation of this movement allows the kinetic energy of the leg to extend the knee and this may also be assisted by the fitting of a spring Then hip extension, at the moment the heel touches the ground, ensures locking of the knee and at the same time starts to bring the body forwards over the artificial foot in the same way as in a normal leg Meantime the movements described above have been proceeding in the artificial foot

**The Upper Limb**—The formation of a mechanical hand to replace the natural one is clearly doomed to be the most imperfect substitute at best, and so it has been found more successful to supply a number of tools or tool-holders These are instantly interchangeable, fitting into a chuck on the end of the artificial limb The most useful ones are —

**The Dress Hand** A certain mid hand with curved fingers for carrying and a spring thumb for holding papers or cards A slightly modified dress hand will hold a pen or pencil (Craft, 1944)

**The C-hook** For heavier carrying or lifting

**The Split Hook** This is a C-hook split in its length, having one rigid blade, the other being hinged and held closed by a spring The hook may be opened by carrying the shoulder downwards and forwards, thus putting tension on a cord passing from the opposite shoulder to a lever on the moveable blade This instrument is the best prehensile tool that has been devised Other tools may also be fitted, and all are capable of being passively rotated in the chuck to the desired position

In the control of the elbow in upper-segment amputations (Fig 31), flexion is effected in the same way as opening the split hook, the cord passing through a ring in the forearm section in front of the elbow-joint The other hand can lock the elbow at the angle required, though in some limbs an automatic lock and release is fitted, worked by carrying the scapula rather farther forward and extending the shoulder-joint Passive rotation of the whole arm from just above the elbow is possible, allowing the flexed forearm to be held across the body In above-elbow limbs, the tool chuck is usually situated fairly close to the elbow, so that leverage operates less to the disadvantage of the wearer

**The Phantom Limb**—The phantom limb is present in over 80 per cent of cases after amputation The sensation is similar to, though never quite the same as, that of the intact limb (Riddoch, 1941)

In the course of time the phantom often tends to shorten, so that the toes and fingers, of which awareness is normally greatest, close up on the stump end and may even recede right within it Now the phantom limb in leg amputations has one outstanding importance When the patient starts to get up, or during the following weeks, the presence of the phantom often causes him to forget the absence of the substance, and he goes unthinkingly to step on it But, alas, the phantom is a phantom indeed The resulting trauma to the stump

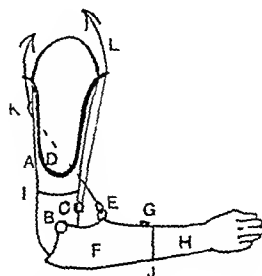


Fig 31—The above-elbow limb A, Socket, B, Elbow-piece and joint, C, Elbow locking and release stud, D, Stump, E, Ring, F, Forearm piece, G, Tool release stud, H, Dress hand, I, J, Points at which passive rotation can occur, K, Pulley over which passes elbow flexing cord to ring (this cord may pass through the ring to the moveable blade of a split hook), L, Automatic elbow lock and release operating cord (this operation is effected with the other hand in the semi-automatic type) (By courtesy of Messrs Hugh Steeper Ltd)

end may cause severe soft-tissue damage, rupture of the suture line, or even result in a fracture, usually in the lower end of the proximal bone It is therefore important that an emphatic warning against this danger be given to every patient when he starts to get up after having lost a leg and be repeated at intervals during his convalescence It is the very rare exception for such a case to get through this period without stepping on his phantom

## OPERATIVE TECHNIQUE

Although the principal points of technique are well known, yet several matters of detail, though minor in themselves, go towards making a stump which will be comfortable, efficient, and healthy, and will have the best chance of remaining so

An amputation stump shrinks, but it is the muscles that waste and oedema that absorbs The skin shrinks little if at all The flaps should therefore be cut so that they just meet over the end of the stump and there should be no redundancy at operation In order to avoid 'dog-ears' at the corners, the incisions outlining the flaps should diverge at once (Fig 32), and if the flaps are cut in a smooth curve they will be a glove fit for the stump

The deep fascia is the normal supporting structure of the skin and the normal covering of bone and muscle In addition, as mentioned above, it is upon its surface that the lymphatics that drain the overlying skin are found If the deep fascia is retained in the flap and is co-extensive with it, perfect lymphatic drainage is assured, the risk of sloughing of the flap margins is eliminated, for no cutaneous blood-vessels will have been damaged, and anaesthesia of the flaps will be avoided, for the terminal nerve-fibrils to them will have escaped

injury as well. The adventitious layer of periosteum, in the case of the tibia, is in continuity with the rest of the deep fascia of the leg and is capable of being separated from the osteogenic layer and reflected in one sheet (Perkins, 1944). The deep fascia is sutured over the stump end before closing the skin.

It is almost proven that painful nerve-bulbs and painful phantom limbs result from a neuritis

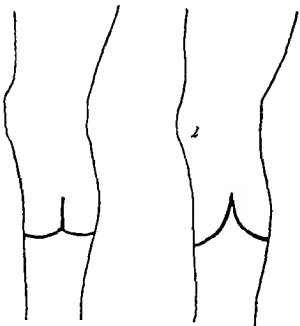


Fig 32—Flap design. Flap cut as in the left-hand diagram will give prominent 'dog ears'

of the divided nerves. They should therefore be spared all unnecessary trauma, being simply divided with the first sweep of the knife. They should not be crushed or intoxicated with alcohol, and in particular every effort must be made to protect them from suffering the dual trauma of section and infection.

Bone and periosteum should be divided at the same level. In getting at the line of section of the fibula, it should be approached extraperiosteally. The tibia wants a very generous bevel with a preliminary saw cut, and apart from nibbling off the subcutaneous corner of the ulna, no other procedures, such as plugging with wax, gouging out several inches of medulla, or filing of the edges, are necessary.

Spending an extra five minutes in hæmostasis will always be well repaid by the lower incidence of post-operative hæmatoma, but drainage, even then, can rarely be dispensed with.

Skin suture should be artistic and accurate (Fig 33). Surgery is an art as well as a science, and a neat stump, besides being physiologically sound, gives the surgeon a justifiable sense of æsthetic achievement. And more important still, it gives the patient a good psychological start to his life as the possessor of an amputation stump.

**Amputation in the Presence of Sepsis**—Of all operations that are designed to heal by first intention, the amputation fails most often, and in the whole series of 406 cases, 232 (57.1 per cent) had suppurred for a shorter or longer period before healing, and this includes 79 consecutive personal cases with 63 (80 per cent) primary healing. Apart from extrinsic causes, there is the intrinsic reason for this that the knife must traverse lymphatics draining the infected region, so giving organisms access to that most suitable pabulum for their propagation, the hæmatoma, which is invariably present, even if in only a small amount.

The seriousness of infection in an amputation stump is essentially that osteitis of the divided bone

so frequently results. Not only may healing be slow and the scar adherent, but prolonged treatment for pocketing of pus and sequestration may be necessary. And the patient has the legacy of a stump which may, and often does, have recurrent flares of infection throughout his life.

Much thought has been given to this problem, and the results fall into two main groups. Amputations which will become the final stump, and amputations done as a deliberate preliminary to re-amputation.

**Primary Suture**—Where sepsis is comparatively remote from the intended site, when it is of long standing, and when it has as yet developed incompletely, as in the intermediate traumatic case, primary suture is permissible. But it is performed with the reservation in the surgeon's mind that if, at the time of removal of the tube in 48 hours, there is evidence of infection, the wound must be re-opened and the flaps turned back.

**Delayed Primary Suture**—Jack and Charnley (1943) described an operation designed to meet the problem, the principal object of their attack being the hæmatoma. This they attempt to eliminate by dry gauze packs kept under the flaps for 5 days, when delayed primary suture is performed, and by combining with this method the local use of sulphonamides. By doing so they aim at saving the patient a subsequent re-amputation. Of 32 such cases which have fallen into this series, 15 healed by first intention, though the remainder were, with 3 exceptions, the site of soft-tissue infection only. Though this is an improvement, it still falls short of the ideal result aimed at.

**Secondary Suture**—Here the flaps are sutured back at the original operation and secondary suture



Fig 33—Accurate wound suture and correct flap design produces a neat stump. Photographed on the twelfth day after amputation.

is performed when the bone is covered by granulation tissue, usually about 14 days later.

But there remains a proportion of cases where the infective process is too close or too acute for any reasonable hope of primary healing by any of the above methods.

**The 'First Aid' Amputation**—This is a very low amputation in which some degree of infection is expected, but which allows plenty of room for re-amputation when the sepsis has been controlled.

**The Guillotine**—This operation has a very useful place when the patient can remain in the same hospital for an adequate period. Its virtue is that



# THE MAJOR AMPUTATION STUMP

37

there is such perfect drainage and complete absence of tension that infection does not involve the stump or the bone, and its lack of flaps allows it to be carried out very close to the lesion if necessary, thus allowing as much room as possible for subsequent reconstruction

## POST-OPERATIVE MANAGEMENT

The post-operative treatment of a stump is almost as important as the operation itself, and it begins in the operating theatre. Over the usual dressings a firm elastic bandage is applied and this is retained for 24 hours. In addition, in below-knee sites, a simple back splint is applied to keep the knee in full but not forced extension. This splint remains in place for 12 days, and is completely effective in preventing the marked tendency to flexion contracture without subsequent stiffness. The same trend in the hip in above-knee cases is counteracted by bandaging the stump with the hip extended and maintaining the position, if necessary, with a towel and sandbags. Drainage is removed in 48 hours under the strictest asepsis and the wound then covered at once and not inspected again until the stitches come out. Daily dressings, moist swabbing of the wound, and probing or squeezing out hæmatoma are not permitted.

When the stitches are removed on the twelfth day, a crêpe bandage is substituted for the cotton one, and the patient is allowed up a day or two later. From the first, this bandage is kept in use



Fig 34—Correctly applied above knee stump bandage

- 6 It is reapplied whenever it becomes loose, and at least thrice daily
- 7 It is retained in use until the patient starts to wear his limb

Non-resisted exercises are encouraged from the twelfth day, but exercises against resistance (Fig 35) do not begin until 3½ weeks from amputation. Too

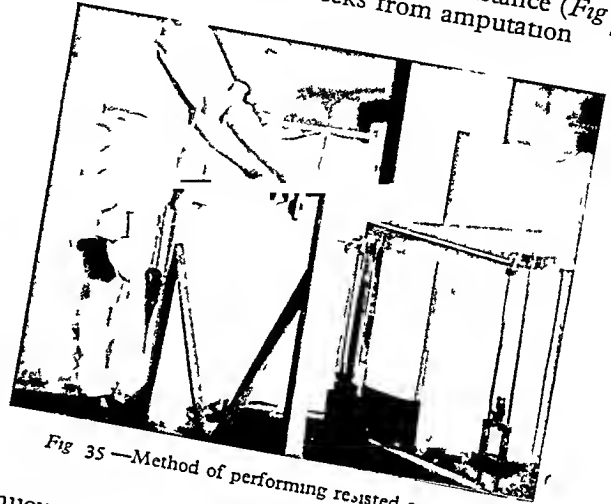


Fig 35—Method of performing resisted exercises

strenuous exertion, even in the absence of local trauma, may be found to induce an aseptic inflammation in the stump, and if this does occur, returning the patient to bed and applying ice-bags will usually bring about resolution in 3-4 days. The exercises are progressive in frequency, number, and degree, and the important movements to strengthen are extension at the knee, extension and adduction at the hip, flexion and extension at the elbow, and abduction at the shoulder. With this regime and the retention of the deep fascia in the flaps, a stump is now ready for measuring for an artificial limb in 4-6 weeks and is ready for limb-wearing by the time the limb is made. Not until the patient is finally fitted with his limb should he pass from supervision.

**After-treatment of a Guillotine Amputation**—The main arguments against the guillotine amputation are that there is great pain with dressings, that the skin retracts, often with projection of the bone end, and that healing is slow. I have modified a form of treatment originally described by Bunyan (1941) and find that it works excellently. As soon as hæmostasis is secured at operation a Bunyan Stannard envelope is applied with the seal close to the skin margin. After irrigation with hypochlorite, the bag is closed and skin traction instituted by adhesive strapping attached to the outside of the seal. A Spanish windlass type of fixed traction apparatus is attached to the end of a Thomas' knee splint in the leg (Fig 36), or a Jones' humerus extension splint in the arm. As the function of this traction is to prevent retraction rather than to pull the skin down, the tension only needs to be light. Irrigations are performed three times a day, and the patient can carry the splint over the side of the bed from the first, so as to allow free egress of the irrigating fluid into a bucket. There is no pain after the first 48 hours, and even during that time it is often less than following an

- and its tension is gradually increased (Fig 34). The principal points in its use are —
- 1 It is stretched and rolled immediately before application
  - 2 It compresses the end of the stump and especially the corners
  - 3 It does not tend to form a 'waist'
  - 4 It includes the whole stump, particularly in the adductor region
  - 5 It does not prevent movement in the joint, which it usually includes



ordinary amputation Dressings are painless as the silk does not adhere to the raw surface and this may even be palpated through the silk without the patient suffering any unpleasant sensation He has an additional interest in that he can help with

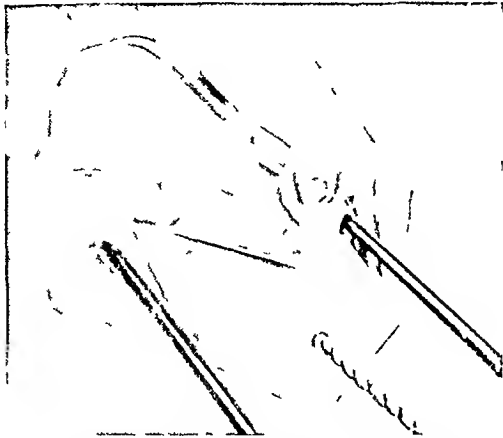


Fig 36—Showing combination of Bunyan envelope and skin traction in the treatment of a guillotine amputation (Note the ease with which the wound can be inspected)

the irrigations, and finally, cross-infection is less likely to develop than with any other form of dressing Healing is not unduly delayed, though it might be helped by the application of a Thiersch



Fig 38—Projection of both bones in a stump with severe skin retraction The illustrations show the healed state at the time of re amputation and the final result

graft as soon as the bone end is covered by granulations and before these have had too much of their blood-supply cut off by the developing fibrous tissue

### AFFECTIONS OF THE AMPUTATION STUMP

**Early**—Post-operative pain is almost invariably an indication that hæmorrhage is occurring inside the flaps, and this may be of the reactionary or

secondary type If reactionary hæmorrhage stops spontaneously, no treatment is necessary beyond taking additional precautions to avoid infection and aspirating the liquefied hæmatoma at the time the



Fig 37—Severe infection with widely gaping stump end in a First Aid amputation

stitches are removed But in the case of secondary hæmorrhage or persistent bleeding, the stump must be reopened and the bleeding point secured after

evacuation of the clot Irrigation with hypochlorite during the operation will help to do this and to prevent infection Closure with drainage is then effected

Infection of an amputation stump is, however, a common complication (Fig 37) and may result in complete breakdown of the suture line with sloughing of muscle and fascia and infection of the bone, or less degrees result in abscess or sinus formation Where there is gaping of the wound, an envelope

dressing will be found very satisfactory, as it is for extensive and dirty ulcerations, though it is often wise to employ skin traction or a corset dressing also. Secondary suture may be used in those cases where bone infection is avoided. A sinus or abscess may be the result of an infected ligature knot or

often shrinks to such an extent that it can be excised and the stump left with a linear scar



Fig. 39—Indolent ulcer in a guillotine stump persisting after partially successful graft

foreign body, but most often a sequestrum lies within, and removal of the cause will promise early healing

Projection of the bone in an amputation stump must be treated in the same way as osteitis, that is, the sequestrum must be allowed to separate (Fig. 38). Re-amputation or excision of the bone end will be shown below to be contra-indicated

The most troublesome stump is that in which some gaping has occurred and there remains in the scar, usually over the bone end, an indolent ulcer (Fig. 39), based on a fibrotic and almost bloodless



Fig. 40—Healed grafted area in a stump which presented originally a very much greater raw area—the partially degloved stump. Excision of the grafted area and local trim will achieve a linear scar

Late—Adherent scars are liable to re-ulcerate on account of their poor blood-supply, and excision or local re-amputation will become necessary, though many such scars do not prevent successful limb-wearing. Where there is much redundancy,



Fig. 41—Healed but deeply sulcated stump. The right-hand picture shows the result of excision without exposing the bone end

bed. The main indication is to improve the blood-supply, and Bier's hyperæmia, contrast baths, vascular and general exercises, and various forms of thermo- and actino-therapy all have a place in treatment. A local 'flare' of infection usually results in rapid and complete healing. Excision and suture or Thiersch grafting is again successful in some cases, though it should be done without exposing the bone, and the latter, while a useful adjunct to obtain healing, does not give a satisfactory permanent result. Partially 'degloved' stumps should be grafted at the earliest opportunity (Fig. 40), and the grafted area

puckering, or 'dog-earing', intertrigo is liable to develop in the sulcus which is present when the stump enters the socket, and the treatment is to perform a plastic repair when the skin infection has been controlled (Fig. 41). Dermatitis of the skin of the stump is not uncommon, and may prevent limb-wearing, the most usual type being a low-grade infection of the sweat and sebaceous glands in the adductor region, or more rarely around the head of the tibia. Rest allows the infection to settle, but recurrence of infection in these glands is frequent. Sometimes changing the material of the

socket or corset of the limb will help, but prevention of re-infection by scrupulous cleanliness is more often successful

Anæsthesia, hypo-æsthesia, or hyperæsthesia have been found in nearly a quarter of the amputation stumps examined. Except where amputation has passed through a previously insensitive area, as the below-knee operation following sciatic injury, these complications are completely eliminated when the operation has included the deep fascia in the flaps. And it is desirable to avoid them if possible, for trophic ulceration sometimes appears in such areas with use of the artificial limb.

Bursitis is most commonly found in the bursa over the tubercle of the tibia. It is usually non-suppurative and subsides with rest, but occasionally suppurates and needs drainage. If recurrent inflammation is troublesome, a 'soft section' can be let into the contiguous part of the socket, polycentric knee-joints fitted, and the corset extended so as to become tuber bearing, thus taking the weight off the tibia and reducing friction and pressure.

Flexion contracture is found in 30 per cent of cases in which no special steps are taken to prevent it, and prevention is very much easier than cure and has already been described. It is in the first week after operation that most of the damage is done. Where present, splintage at night in the corrected position and exercises to strengthen the extensors will reduce the deformity, but minor degrees may remain. They can be allowed for to some extent by tilting the socket in the artificial limb and use of the limb will produce further improvement.

Fracture of a stump is uncommon for mechanical reasons, but more usual is the fracture of the lower end of the proximal bone in a lower segment amputation. As weight-bearing is not involved, plaster following reduction need be retained for 2-3 weeks only, when efforts may be bent to restoring the function of the intervening joint. A spur, as noted earlier, is almost invariable. It is only very occasionally that it requires removal.

The sensitive shiny, trophic-looking stump, often with a tender superficial neuroma, may be said to have entered the phase of stump intolerance of the nerve type. As with painful phantoms and painful neuromata, re-amputation is not often successful in relieving the symptoms. In all these conditions which are closely allied and which seem to be associated with a neurotic personality to some extent, social and economic factors may have some causal relationship and their solution is often followed by improvement. If pain is very severe, neurectomy only occasionally relieves the condition, and it may be necessary to resort to sympathectomy, or even cordotomy (Taylor, 1938).

The other type of stump intolerance is the vascular. This appears, usually for no obvious reason, after limb-wearing has proceeded for some years. As a rule, it is found in stumps that are rather longer than ideal, whose extremities lie in that part of the segment where the blood-supply is the least efficient. They present as a sort of cellulitis of the stump end, which is swollen, dusky, and feels very thickened, but is not particularly tender. It refuses to localize and will either not subside properly or, if it does, will not stay quiescent on

resumption of the limb. Other cases simply have a stump that is blue and cold. The only treatment which has any permanent value is to give the patient a stump that terminates at a level where the blood-supply is more satisfactory, though this occasionally involves the sacrifice of a joint.

## RE-AMPUTATION

The indications for re-amputation include the completion of a two-stage amputation, certain types of adherent scar and repeatedly ulcerating scar where there is not enough skin to allow excision

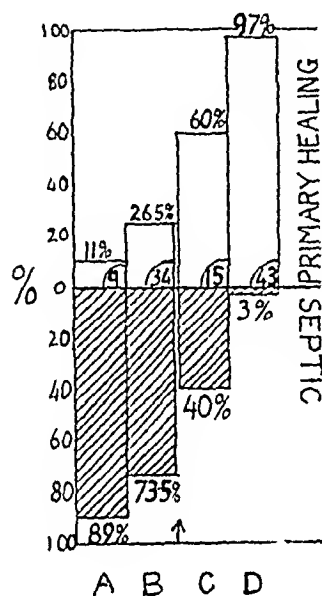


Fig. 42.—Percentage results in 101 re-amputations. Group A, Re-amputation in the presence of projecting bone; Group B, Re-amputation in the presence of an open wound; Group C, Re-amputation within six weeks of healing; Group D, Re-amputation six weeks after healing or later. The number of cases in each group is indicated. The arrow points the moment of wound healing.

and suture, failure of stump tolerance of the vascular type, and excessive length when coupled with any abnormality of the stump end. The object of re-amputation is to produce a perfect stump which will last the patient his lifetime, and to this end it is essential that there should be an appreciation of the possibilities and risks involved.

From the study of 101 cases of re-amputation in this series of 406 amputation stumps, some very clear facts emerge (Fig. 42), and these may be summarized by saying that not until an amputation stump has been healed for six weeks can re-amputation be embarked upon with any certainty of obtaining primary healing. Re-amputation falls into the same category as bone-graft, arthrodesis, or osteotomy, in that a compound fracture is being inflicted on the patient. It is equally important in all these operations that there should be an absolutely aseptic field. To perform re-amputation in the presence of an open wound is a violation of the basic principles of surgery, and cannot be condoned even when associated with the use of the sulphonamides or penicillin.

Even when the operation is performed where there is a so-called 'clean ulcer', the probability of infection is as high as three to one, and if it ensues the patient is in a worse state than before, for all the time that has elapsed since the original amputation has been wasted and in addition the valuable length that might have been properly used at the right time has been lost.

Sequestration must be awaited, healing obtained, and then, when this is sound and there has been no infection present in the stump for at least six weeks, re-amputation will be followed by a perfect result. This policy of adhering to first principles will amply justify the time that has been invested. The patient can almost always be persuaded to wait the full time. It is much more difficult to contain oneself.

### SUMMARY

- 1 The amputation stump must be considered as a normal organ
- 2 Its anatomy and physiology are described
- 3 Emphasis is laid on detail in the performance of the operation and the after-care of the stump
- 4 Some of the more important affections of the amputation stump are described and their treatment indicated
- 5 Re-amputation must achieve perfection, to which end it must be performed in an aseptic field

I am indebted to Sir Walter Haward, Director-General of Medical Services of the Ministry of

Pensions, for permission to publish this essay, which does not necessarily represent the views of that Ministry, to C Gordon Irwin, Esq., for all his encouragement and wise guidance, to all members of the staff of Dunston Hill Hospital for their co-operation and enthusiasm, and to Messrs Hanger Ltd and Messrs Steeper Ltd, both of Roehampton House, S W 15, for their permission to describe and make diagrams of the artificial limbs developed and manufactured by them.

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## ASEPSIS IN PROSTATECTOMY

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*I look into that happy future when within the lying-in Hospitals and also outside of them throughout the whole world only cases of self-infection will occur*—Semmelweis (last words, 1861)

*It would be a grand thing if we could dispense with drainage altogether*—Lister (*Brit med J*, 1892, 2, 377)

FROM the days of McGill prostatectomy has always been a septic procedure, for the following reasons. The urethra below the enlarged prostate is rarely germ-free and yet catheters are invariably passed through it, the prostate-blocked bladder is often infected, the tract is known to be tolerant to infection and so liberties are taken with it, it is at times an excretory channel for microbes, the rectum is adjacent, and, lastly, there are apparent technical difficulties in an aseptic approach to the prostate. Uncleanly practice has become so firmly established by long custom that many meticulous prostatectomists have considered, and still consider, themselves to be scrupulously, surgically clean.

This paper describes an attempt to emulate the standards of asepsis of the brain and knee-joint surgeon, it is the record of an experiment to avoid any addition of bacteria or, what has proved equally if not more important, the access of any fresh strain of bacteria, to the urinary tract. The experiment has been conducted over six years in over six hundred cases. The results have been startling.

In the early days of the experiment it became obvious that even greater aseptic vigilance was

necessary when the urine was pus-laden than when it was sterile. If the patient had become immune to his infection good results, with healing by first intention, were obtained by aseptic technique.

### DANGER OF SLOW DECOMPRESSION AND OF DRAINAGE

Twenty-five years ago slow decompression became necessary because slow infection was necessary to allow time for immunization. Rapid decompression with its rapid ascending infection killed. The chief virtue of the preliminary suprapubic tube and of the indwelling catheter was to cause infection and to permit the patient to develop his own immunity—if he could—before proceeding to prostatectomy. Immunization is of greater import than reduction of blood-urea because, as will be shown, post-operative uræmia is almost entirely the result of sepsis. Slow decompression is harmful because it must lead to infection even if it does not lead to the production of pyuria. Moreover it is unnecessary. In over one hundred cases of chronic retention of urine, varying from one to five pints, I have in one minute decompressed the

bladder aseptically without any ill effect. The subsequent rise in blood-urea after the rapid decompression in 'aseptic prostatectomy' is less than the rise after slow decompression either by a catheter or a suprapubic tube. Ten cases with initial blood-urea values between 50 and 120 and with one pint or more of chronic residual urine were drained suprapubically by slow decompression, and blood-urea estimations were taken twice daily for five days. The greatest rise in each case was noted and the average of these in the ten cases was 26.5. A similar investigation done after ten 'aseptic prostatectomies' showed the average highest rise to be 9.2. The highest rise in the first group occurred most frequently on the third day after operation, in the second group on the first day. This is due to the fact that in open slow decompression organisms can and do travel up the ureters, often dilated, and diminish renal function. It is quite true that when very large quantities of urine have been suddenly evacuated during my operation the vesical surface of the big prostate may be seen to bleed profusely from sudden diminution of tension. This accounts for the hæmaturia seen a few hours after rapid catheter decompression. This does not matter when the prostate is removed immediately and hæmostasis effected by the method described hereafter. The relief of great tension occasionally causes visible congestion of the bladder and presumably of the kidneys, but it does not result in the blood-blocked kidneys found sometimes in the old days after rapid decompression. This must have been the sequela of ascending infection.

The increase of uræmia after surgical interference—by operation, catheter, or drainage—is due almost entirely to infection. Operation trauma plays a relatively small part. I passed catheters through thirty normal urethras, with every aseptic precaution, and then sent them for culture. In 83 per cent organisms of some sort were grown. Some were non-pathogenic, but these of course prepare the way for the pyogenic organism if catheterization is prolonged. How much earlier will full sepsis appear after catheterization in a urinary tract blocked by the disordered prostate? Therefore, I suggest that neither the catheter nor the suprapubic tube can have any place as a preliminary to any aseptic procedure. The damage done by these two drainage methods has not been undone by the inventions of ingenious urologists, by the principle of slow decompression, or by the various therapies. Would any surgeon consider a catheter which had traversed even a normal urethra a fit tube to drain any aseptic cavity elsewhere? The prostate-blocked bladder needs as great a respect as the brain and the joint because the urine is a fertile field for organisms, because the prostate itself is a nest in which they may lurk, and perhaps because the tract itself may become the channel for the excretion of organisms.

### HÆMORRHAGE AND ASEPSIS

The chief difficulties in prostatectomy are the control of hæmorrhage and sepsis. Obviously the only clean approach to the prostate can be the suprapubic one. The skin of the perineum is laden with organisms, and the transurethral route can rarely be aseptic.

**Concerning Hæmorrhage**—For over a dozen years in my practice hæmostasis has usually been effected by diathermy. The hæmostat attached to the diathermy cable is generally a fine-pointed Spencer-Wells fine-pointed because the bleeding vessel must be picked up lightly and finely so as to produce only a minute carbon mass. The type of hæmostat can be varied to suit the surgeon. Stile's, Lane's, or other forceps are occasionally used. The current is controlled by the surgeon's foot, and the patient properly protected. The surgeon using only one hæmostat throughout the operation naturally saves innumerable movements. He can in a few seconds seal a dozen or more vessels caught by his assistants. The saving of time, labour, and bleeding in many operations, such as the radical breast operation, is enormous. More perfect hæmostasis is obtained in any wound, because the surgeon takes the trouble to stop every tiny oozing point which he could not, or would not, trouble to deal with by ligature. Bleeding in remote and hidden places can be more easily sealed. A radical breast amputation is done in a third less time, with less exertion, bleeding, and shock. Most named arteries are ligated. The average number of ligatures in the radical breast is twelve, in a subtotal thyroidectomy six. With an efficient assistant working his own diathermy only half a dozen hæmostats are necessary for any operation.

In the three hundred consecutive prostatectomies here reported no single ligature has ever been used anywhere in the course of the whole operation. After the prostate has been removed every bleeding point is finely and meticulously and with infinite patience picked up and lightly coagulated. Widespread destruction by coagulation, with consequent big sloughs, has no place in aseptic diathermy. This way leads to sepsis. Hæmostasis at the margins of the mucous membrane is easy, it is more difficult in the depths of the prostatic bed. Access is made easier by the commonly advocated removal of the V-shaped, or semicircular, portion of the trigone, by means of a 'live' needle held in the jaws of the hæmostat. The V is a very large one, often running to within a quarter of an inch of the ureters and the apex to near the inter-ureteric bar. This gives a very large opening into the prostatic funnel. Oozing is nearly, but never entirely, stopped.

The systolic blood-pressure is constantly taken by the anaesthetist. A spinal anaesthetic is invariably used and anaesthesia should never pass up to the umbilical level. A sudden great fall in the blood-pressure is thus usually avoided. Spinal anaesthetic shock is a bad beginning for any old man undergoing a prostatectomy. Corrective measures are taken immediately if the blood-pressure falls below 100. Methedrine (0.25 c.c.), or other vasopressor, is always injected intramuscularly when the enucleation begins. If the blood-pressure does not rise sufficiently, another 0.25 c.c. or less is injected very slowly into a vein. If it is injected quickly nausea and even vomiting may result. The blood-pressure should go up to the neighbourhood of 130 before the hæmostat is put aside. Any blood-clots are removed by suction and not by a swab. Quickly a couple of ounces of 5 per cent sodium citrate solution are

put into the prostatic bed and bladder to prevent the formation of further clots

A rubber tube is then passed from the bladder through the urethra in a retrograde fashion. The wall is 1 mm thick and the lumen may be either 5 or 6 mm in diameter, the bigger size being used whenever possible. The rubber tube, 18 in long, has at least two holes cut in it proximally and anteriorly in the concavity of its curve, so that there are three openings remaining in the bladder and the prostatic cavity. To pass it the distal end is tied to a black French bougie with its bulbous proximal end cut off. The rubber tubing and bougie are well plastered with acriflavine-vaseline, which it is hoped will act as a pack around the tube within the urethra. The attached remnant of the prostatic urethra will act as a guide to a preliminary sound if it is not cut off until the tube has been passed. Whilst withdrawing the sound the black French bougie takes its place and is passed through the urethra and pulled out by an assistant until the holes in the tubing lie properly and anteriorly, the most distal being almost at the membranous urethra. This is the hardest technical point in the operation and if it cannot be done the prostatectomy is not an aseptic one. If a stricture of the urethra, or some other obstruction, or want of practice of the surgeon, necessitates the passage of an instrument through the urethra from without inwards, then every known antibacterial measure must be taken during the days following the operation. Nevertheless this apparently doubles the mortality risk. I find it necessary in 3 per cent. The bladder should be invariably securely and completely closed.

Immediately after the abdominal wall has been closed, the bladder is suctioned to evacuate citrate, air, and any blood-clot, the last being rare. From two to ten ounces, according to the original size of the bladder, of sodium citrate solution is left in the bladder and a spigot is inserted. This spigot is removed about two hours after the operation and the tube connected up by further sterile tubing and led into a sterile Winchester containing sterile water. If during the next twenty-four hours signs or symptoms of blocking appear, powerful aspiration of the urethral tube is tried and if unsuccessful, half-an-ounce of 5 per cent sodium citrate solution kept sterile by formalin (1-500) is used to clear the drainage catheter, not the bladder. This is necessary in 15 per cent of the cases. The urine takes from one day to one week to become clear, but if the clearance is delayed for more than three days infection must be suspected. Reactionary hæmorrhage ought not to occur, but it necessitated reopening the bladder three times in my first 90 cases. This has never been required in the last 300 consecutive cases described in this paper. This, of course, is less than in any other form of prostatectomy. Late secondary hæmorrhage requiring opening of the bladder does not occur because it is always the result of sepsis. Hæmaturia not requiring interference has occurred in the presence of sepsis, it indicates cystitis.

**Concerning Asepsis**—Since bacterial invasion is the only practical cause of increased uræmia, all investigations requiring mechanical interference must have been completed at least two weeks before

the operation and the patient must have recovered in every way. The surgeon has a much easier problem than the physician, he can decide the zero hour for the attack by the bacteria—the operation. Consequently general pre-operative anti-infective measures must be taken.

I use endocrinotherapy and mild chemotherapy, usually for some days and always during the twenty-four hours preceding the operation. Because I have long held the opinion that certain endocrines possess an anti-infective factor, I have used protamine-zinc-insulin (8-20 units) mixed with adrenaline (3-6 mm) on the night before the operation and for the subsequent seven days. If pyrexia follows the operation the insulin and adrenaline are increased. This endocrine treatment, based perhaps on erroneous theory, my inconclusive animal experiments, and much observation and practice, may be unsound. Insulin alone can be harmful but the doses used will not produce dangerous hypoglycæmia if proper precautions are taken, and the nursing staff are trained to be hypoglycæmia-minded. It is certain that this aseptic prostatectomy can be carried out without endocrines, but undoubtedly not with the best results.

Throughout the operation the highest, almost finicky, standards of asepsis are aimed at. It is better to use fresh gloves and instruments after the skin incision and fresh gowns and gloves after the removal of the prostate. The removal should always be done with such gentleness as is impossible without a steady finger in the rectum. The one-handed enucleation in the easiest case has been abandoned. All tissue which might form a nidus for bacteria is removed. Tags, sloughs, protuberances, and blood-clot are cleared. Plastic flaps to cover the prostatic bed and all suturing and ligaturing are avoided. The prostatic bed is smoothed off with the diathermic needle and hæmostat. The cut edges of the bladder are sutured in apposition without any of the fine catgut piercing the mucous membrane, which is not inverted. The catgut is in three series. The bladder is never sutured to the abdominal wall, it remains as before, free and mobile. The pouch of Retzius should be eliminated by sutures, but if it is a big one it can be drained for twenty-four hours. Drainage tubes here as elsewhere can be dangerous, an exit for pabulum is an entrance for bacteria. The hermetically-sealed abdominal wound need be inspected only once—to remove the sutures.

The catheter tube draining the bladder is the weakness of this operation. It must always be a route for ascending infection. The route may be inside the tube even though there is a three-foot sterile connexion into a Winchester of dettol, or outside, between the rubber and the urethral wall, although packed with flavine-vaseline. I have attempted unsuccessfully to paralyse temporarily the external sphincter with proctocaine, etc. When this is possible this catheter tube will not be required and prostatectomy will become a 'closed' operation. This urethral tube at the moment is a necessity and a danger and the sooner it is out the better. The tube is removed any time between seven hours and seven days. The normal time is four days. It is immediately removed when an irremovable

block has occurred within it and when there is the slightest evidence of infection. The first indication of the latter is almost invariably a rising pH of the urine.

In infection in other parts of the body the earliest warning of a bacterial attack is usually a rising temperature. It is observed perhaps twenty-four hours after the bacterial offensive has begun and consequently not until it has gained ground does the surgeon take up his defensive therapy. After prostatectomy the first indication is a change in the reaction of the urine. If the nurse removing the urine bottle, or better still the intelligent patient every time he passes urine, will test the reaction with litmus paper, the counter-attack can often be launched so early as to nip it in the bud. Speed in taking the defensive is as essential in bacterial as in other warfare. Hours count. The old and new therapies are used intensively the moment the litmus turns blue, not a day or two later when the temperature goes up.

When the urethral tube is removed the operation area is closed. Nevertheless, infection, presumably autogenous, may occasionally occur—most commonly about the seventh day. Since the prostatic bed, even with an aseptic operation, may not be completely epithelialized for ten weeks, this infection may occur as late as six weeks after operation (1 per cent).

A patient with infected urine before operation almost invariably reports later with clear uninfected urine. My old septic prostatectomies too often returned with urine more or less permanently infected. That operation in one or two stages was a septic incident in the lives of old men, many with damaged cardiovascular or other systems. This is a matter of great import. It may be the explanation of the relatively short longevity after many successful prostatectomies. The rare occurrence of infection after 'aseptic prostatectomy' explains the almost complete absence of thrombosis and embolism.

### PRE-OPERATIVE PYURIA

Pre-operative pyuria does not affect the procedure. The ultimate results are not much worse than in the aseptic bladder. Strangely enough the abdominal wall rarely becomes infected. Sulphanilamide powder is unnecessary and may be harmful.

Even the patient who has had a suprapubic drainage for three years, with all its attendant sepsis, has become so immune that his wound will heal after this prostatectomy almost by first intention. Absolute asepsis is, however, essential in these septic cases. The fouler the urine the more rigidly aseptic must be the technique. Cloudy, purulent, turbid, alkaline urine will frequently become clear and acid within a few days after prostatectomy.

A double vasectomy is advisable only in the presence of pyuria.

### ACUTE RETENTION

In acute retention no catheter is passed if the diagnosis is certain. Intensive intramuscular chemotherapy and other treatment is immediately instituted for as many hours as possible. To relieve pain during these hours, if morphine is insufficient, bladder tension is reduced by the insertion of a fine spinal

needle. The full prostatectomy is then carried out in the normal way. Haemostasis is more difficult and time-consuming than in the quiet case.

### THE MALIGNANT PROSTATE

Malignancy has been demonstrated by the pathologists in 18 per cent of these cases and actual malignancy has been missed by them. Especially in 'enclosed' cancer the surgeon should pick out the clinically malignant piece for microscopy. Early malignancy has most frequently been found in the posterior lobe near the right seminal vesicle. My practice is to remove the prostate with its capsule as nearly as possible *in toto* with the vesicles. Risks are run of damaging the rectum and ureters, actually they never have been damaged. When total removal appears impossible a wide diathermic excision, not coagulation, is done with one finger in the rectum.

Castration is carried out at the same operation to diminish the stilboestrol load.

### CONCOMITANT OPERATIONS

With patients in good condition other operations are frequently performed at the same time with impunity. Vesical stones and growths are removed. Medium-sized diverticula are excised and very large ones have been drained by a deep gutter into the prostatic bed, usually necessitating opening the peritoneal cavity. Herniotomy and haemorrhoidectomy are common, removal of hydrocele and appendix occasional. The abdomen is explored at the slightest provocation, and on five occasions in the present series cancers of the pelvic colon have been found and the Paul-Mikulicz operation carried out, it is quite possible that the colon cancer was as much responsible for the urinary disturbance as the prostate.

The prostate has been removed when it has caused retention after an operation for colon cancer, haemorrhoids, or hernia. It is far better, however, to do multiple procedures at one operation. Prostatic resection following an operation for another lesion is never aseptic because it always follows the passage of catheters. In no case has a multiple operation been fatal.

### AFTER-COURSE

The patient is out of bed every day after the operation if only for a few minutes. Rapid rehabilitation is enthusiastically encouraged. Chemotherapy, which consists of no more than 1 g of sulphamethazine or sulphathiazole every six hours, is stopped on the fourth day but is renewed with the greatest intensity at the slightest sign of sepsis. Occasionally he goes home nine days after the operation, the normal time is thirteen days, and the average stay in hospital of these 300 cases is 16.3 days, excluding the fatal cases. Five patients have required treatment for stricture of the penile urethra due to tube pressure, and three for late cystitis. Malignant cases have returned for castration. There have been no cases of incontinence.

Retention of urine from spasm of the external sphincter very occasionally occurs in highly nervous individuals after the urethral tube has been removed. This is dealt with in the usual way by baths, hypodermic antispasmodics, and so on. It is better to



run the risks of a leaking bladder than to pass a catheter, but it is wiser to pass a catheter at the last moment than let the bladder leak suprapubically. It is wonderful what a well-stitched bladder after a few days' aseptic healing will stand. About 4 per cent of all cases leak suprapubically, this is in debilitated men who have had uræmia.

High degrees of uræmia are treated by an insulin-adrenaline-glucose drip, alternating with sodium sulphate (4.3 per cent). The insulin drip contains 20 units of ordinary insulin and 10 mm of adrenaline to the litre of 5 per cent glucose. Solutions much stronger in insulin and adrenaline are used where the nurse in charge understands hypoglycæmia and is prepared to inject 50 per cent glucose into the tube at the entrance to the vein if required. Most patients with a blood-urea of over 120 are better with a pint or two of plasma. Hypoproteinæmia in the presence of a high blood-urea demands the maximum plasma infusion. Cases with blood-urea over 200 are always in this category. My results would have been better if this most important factor had been realized earlier.

### MORTALITY

The published results of prostatectomy in the past have been deficient in facts. In the extensive literature of prostatectomy I can nowhere find a series of cases in which the surgeon records the number of consecutive cases of prostatism examined, the numbers refused operation by him, and operations declined by the patient, the numbers in which an attempt was made to prepare the patient for operation by medical measures, by the catheter, and by the suprapubic tube, and the deaths occurring during that preparation. We are certainly always given the mortality of the operation itself. We should like to know the numbers condemned to a permanent suprapubic life. We must certainly know the average length of life for each age after the particular form of operation has been carried out. Only then shall we be able to assess the value of prostatectomy. The pre-prostatectomy mortality has probably always been greater than the post-operative mortality. Consequently prostatectomy mortality by itself is of little value.

I have divided all my 'aseptic prostatectomies' into two series, and this is a report on the second series—the last 300. The first series was too complicated by very many experimental methods of hæmostasis and asepsis to be of permanent value. Benign and malignant cases are all included.

In this series 335 cases of definite prostatic obstruction were seen. I refused to operate on 6 because death was too imminent in 5 and 1 was sarcomatous, 29 either refused or postponed operation, or went elsewhere, and 300 were operated upon. Every patient who had any chance of surviving the operation was accepted. For the purposes of evaluation they were divided into four groups—

**Group 1** were perfect cases. There was no marked general systemic disease but they were of any age up to 86. The residual urine at the operation was 6 oz or under. Indigo-carmin was passed per urethram in under ten minutes and the urine was normal, usually acid, and the blood-urea 50 or under.

**Group 2** had mild systemic disease, an indigo-carmin output of fifteen minutes or less, a residual urine of under 15 oz, and a blood-urea of 80 or under. The urine was often infected. Sometimes the pyuria was marked.

**Group 3** had marked systemic disease, usually cardiovascular. The residual urine ranged from one to five pints, and consequently any output of intravenous indigo-carmin was usually never seen, at all events until the following day. The blood-urea commonly varied between 80 and 200. Many of these patients had previously been offered a permanent suprapubic drainage or had been refused operation altogether. Many cases came in ambulances and some were dehydrated by uræmic vomiting.

**Group 4**—All these cases had blood-ureas of over 200 and showed evidence of cardio-renal failure, with œdema, uræmic anæmia, or vomiting. This group expresses an attempt to find the limit of 'aseptic prostatectomy'.

This grouping is obviously arbitrary, indecisive, and in some respects unsatisfactory. Other surgeons would alter the groupings. The figures given below are given with diffidence. My standard for prostatectomy in my pre-aseptic days would have ruled out the whole of Group 4 for any procedure whatever and also many of Group 3, and the rest of Group 3 would probably have been doomed to a permanent suprapubic drainage. All deaths within three months of the operation, from whatever cause, are included.

	OPERATIONS	DEATHS	
		Numbers	Percentage
Group 1	189	4	2.1
Group 2	74	5	6.76
Group 3	31	5	16.1
Group 4	6	4	66.6
Groups 1 and 2	263	9	3.4
Groups 1, 2, and 3	294	14	4.7
Groups 1, 2, 3, and 4	300	18	6.0

It will be understood that the above figures can only be compared with the old 'septic prostatectomies' if the pre-operative mortality could be included. The pre-operative mortality with suprapubic drainage has been estimated at from 15 per cent to 25 per cent, with indwelling catheter drainage at about 5 per cent. It is obviously impossible to arrive at comparable figures. My mortality now, however, is probably about one-fifth of what it was six years ago.\*

Cases of acute retention have been grouped according to their estimated condition before the obstruction became absolute since this incident does not appreciably affect the mortality. Nineteen cases of 'permanent suprapubic drainage' were prostatectomized, these were grouped according to their condition at the time of the operation, usually in Group 2. These obviously must originally have been Group 3 cases and the prolonged drainage put them into Group 2. This fact merits careful consideration, but it must be remembered that these were the survivors of a much larger series.

Since writing this paper the subsequent 126 cases have resulted in 4 deaths. Two of these 4 had been catheterized shortly before admission. The inference is clear.

of cases destined to permanent suprapubic drainage. They had as good an after-history as the ordinary cases. The urine cleared in a few days, and the contracted bladder often recovered its normal volume and tone.

### DISCUSSION

Hæmostasis and asepsis must obviously run hand in hand without the one the other is impossible. If either of these is wanting any closed prostatectomy is likely to be more dangerous than the old operation. Formerly the operation was an incident in treatment, now it is almost everything.

If the above principles are faithfully carried out there is distinctly less anxiety for the surgeon than after the average abdominal operation in old men. Further experience and improving anti-infective therapy are likely to make prostatectomy such a safe and simple operation as will induce patients to come early. The perineal route must always be a septic one and does not permit an abdominal exploration, which is often advisable.

The transurethral method must obviously keep its place for special types of prostatism, but it must always be septic and incomplete. It can never hope to cure malignancy, in 'enclosed' cancer the radical operation may often do so. It must always

be a more difficult and highly specialized procedure than 'aseptic prostatectomy'. The operation is done through the delicate, often infected, urethra with limited vision and limited range of movement. Thus asepsis, wide removal, and good hæmostasis are difficult. The operation is often of longer duration and the shock as great and the blood-loss as much or often more. The after-treatment is more exacting, and complications, immediate and remote, are more frequent. To Lister, the urethral route would be surgically unsound. The duration of treatment and the average total stay in hospital is longer than in 'aseptic prostatectomy'.

### SUMMARY

1 The principles of an aseptic suprapubic total prostatectomy are described and assessed.

2 It is suggested that post-operative uræmia is due to infection and is encouraged by any method of slow decompression, open drainage, or instrumentation. Slow decompression in chronic obstruction is unnecessary.

3 The importance of avoiding a septic procedure and of not leaving a permanently infected urinary tract in an old man is stressed.

4 'Aseptic prostatectomy' should reduce the overall mortality by at least 80 per cent.

## THE ABDOMINAL WOUND IN THE FIELD

By GUY BLACKBURN, M B E

SURGEON TO A FIELD SURGICAL UNIT

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SURGEON TO A FIELD SURGICAL UNIT

THE surgery of abdominal wounds is perhaps the best test of the forward surgeon. Here, at least, he has the opportunity of seeing results and keeping his patient for the ten days after operation, on which so much depends. Here, too, he gets some idea of mortality and it is not long before the value of figures and assessment of surgical achievement by statistics are set in their right perspective.

A series as small as 210 cases obviously can only give impressions which might be very different in an analysis of two thousand. The following account, therefore, is an attempt to set out some of the views obtained and to suggest tentative conclusions only.

The factors affecting mortality are so numerous that no detailed analysis will be attempted here—the terrain, type of missile, type of wound, and speed of evacuation amongst them. The presence or absence of associated wounds and the length of operation have likewise to be considered, but, of these, the latter alone comes entirely within the surgeon's domain. It is unquestionably important, but whether it is the duration of anaesthesia, length of time the peritoneal cavity is open, or some other factor that counts for most, is hard to say. The patient's subsequent progress may well be the index, and it is almost a truism that difficulties in post-operative treatment may well be as great or greater than those in the theatre. The patient and his temperature chart illustrate this point only

too clearly amongst the survivors: the autopsy is the only satisfactory criterion in those who perish. It has been our custom, therefore, to do autopsies, where possible, and we have found incontrovertible evidence that they are of great instructive value.

### TREATMENT BEFORE OPERATION

The treatment of an abdominal casualty commences immediately after wounding and resuscitation by the Regimental Medical Officer is very important. This usually consists of warmth and morphine, but he also carries plasma, and its use in selected cases at the R A P or Field Ambulance has saved many lives. In exceptional cases blood has also been used at this level to great advantage.

In this connexion it is stressed that the patients' evacuation should not be delayed for the administration of plasma, but, as soon as the 'drip' is running well and some response has been obtained, evacuation should be carried out with the transfusion running. The importance of this has frequently been shown by cases arriving at an Advanced Surgical Centre after resuscitation and evacuation without an 'in ambulance' transfusion. These cases have usually passed again into a state of collapse, and the second resuscitation has been far more difficult and lengthy than the first. A transfusion during transit will often maintain the initial response and we feel, on this account, that a

greater use of the 'in ambulance' transfusion is desirable

Morphine has usually been given subcutaneously. This is unsatisfactory in the severely shocked patient, owing to slow absorption, and the intravenous route is preferable. This was well illustrated by a recent case arriving at a Surgical Centre in great pain, with dilated pupils and a respiration rate of 30. He had been given 1 gr of morphine in the previous 1½ hours in four separate ¼-gr doses. After half an hour's resuscitation his respiration rate was 8, his pupils pin-point, and he was comatose. Undoubtedly the absorption of this morphine had not occurred until resuscitation had improved his peripheral circulation. Dressing and splintage of associated wounds is, of course, carried out by the R M O, and we have seen a case in which 1 g of pentothal was given to a man with an evisceration who was in great pain. The anaesthesia so induced certainly relieved his pain, but was far from beneficial during the evacuation which followed it. We can, in fact, see no place for pentothal in the primary treatment of the abdominal wound, when an alternative as satisfactory as intravenous morphine is to hand. Speed of evacuation is essential, and as soon as the patient will stand the journey he should be sent on to the Operating Centre. This applies to all cases of definite or suspected abdominal injury.

On admission to the Advanced Surgical Centre the patient is examined and undressed as far as possible. Further morphine is rarely needed. An estimate is made of the resuscitation required, the guiding factors being the blood-pressure, pulse-rate, and state of the peripheral circulation. In this connexion it is pertinent to observe that no single criterion of operability is uniformly dependable. Serial blood-pressure and pulse readings will usually allow of a fair estimate, but either, by itself, may be misleading. Anaesthesia it has to be remembered, involves the administration of ether, which is a stimulant, and the policy of refusing to start with a blood-pressure of less than 100 may not always be reliable. Conversely, it is unwise to attach undue importance to the relatively slow pulse of the average thoraco-abdominal wound. Opening the pleura and peritoneum can so quickly and dramatically alter the whole picture.

Whilst all men with abdominal wounds require resuscitation, it may only be in the form of warmth and rest for half an hour to one hour. The majority, however, have lost blood, which requires replacing in an approximately equal volume to the amount lost. Three pints has usually been sufficient in this series, with plasma to follow as required.

Plasma loss likewise demands adjustment and two hours or more must elapse in the average case before the maximum response is obtained. In others, operation has been undertaken much earlier on account of continued hæmorrhage (especially from mesenteric vessels), gross associated muscle wounds, or prolapsed and strangulated intestine. Apart from these cases, early surgery should never take precedence over adequate resuscitation.

### DIAGNOSIS

The fact that exploratory laparotomy in a man suffering from multiple wounds carries a mortality

of 20 per cent stresses the importance of arriving at a correct diagnosis whenever possible (Edwards, 1944). Lesions such as extraperitoneal hæmatomata, chest wounds, fractures of the ilium, spinal wounds, extraperitoneal wounds of the urinary tract, and blast injuries may present symptoms and signs strongly suggestive of intra-abdominal mischief; yet, like wounds of the liver and some older wounds associated with localized peritonitis, they can be treated conservatively. In all, these cases form about one-third of the number to whom the label 'abdominal wound' has been applied at some stage of their evacuation.

In many cases generalized rigidity and tenderness of the abdomen, absence of respiratory movement, and silence on auscultation clearly indicate peritonitis. In others prolapse of viscera makes the diagnosis obvious. There remain, however, a number of cases requiring most thorough physical examination and much clinical experience before a correct decision can be reached. In these, we believe auscultation to be of the greatest value.

**Auscultation**—This has been carried out in 150 patients with definite abdominal signs, often several times and for 2–3 minutes at a time, to ascertain the presence or absence of peristaltic sounds. The fluid splash of distended loops of gut, moving on respiration, must not be confused with it.

The findings in these cases were —

	<i>Peristalsis Present</i>	<i>Peristalsis Absent</i>
Hollow visceral lesion present	5	83
Hollow visceral lesion absent	62	1

The figures show the significance of the silent abdomen and the value of auscultation in deciding on laparotomy. In cases of blast injury, extraperitoneal hæmatomata, spinal wounds with paraplegia, and hæmoperitoneum mistakes can easily be made unless auscultation is patiently carried out and, often, repeated (perhaps after a period of resuscitation). The series includes only one case (a large retroperitoneal hæmatoma) in which the abdomen was silent although there was no lesion of a hollow viscus.

Conversely, there have been 5 cases with audible peristalsis and a hollow visceral lesion—2 wounds of the small intestine, 2 colonic wounds, and 1 intraperitoneal wound of the bladder. All but the last of these had minimal peritoneal soiling. It would appear, then, that peristalsis is only absent when the activity of the whole intestine has been inhibited by a general peritoneal soiling. The following case, seen in consultation with Lt-Col A J Latchmore, R A M C, illustrates this point well.

A man, wounded by machine-gun, was seen 2½ hours after injury. The entry wound was in the sixth space just to the left of the midline and the exit in the tenth space in the posterior axillary line on the same side. The abdomen was tender, but peristalsis was easily heard. On sitting the patient up to relieve his distress, he complained of severe abdominal pain. He was therefore laid flat once more and now had a silent abdomen with generalized rigidity and tenderness. Operation revealed a large perforation of the stomach and it was deduced that the gastric contents were rapidly spread into the general peritoneal cavity by the change of position on sitting up.

## OPERATIVE TREATMENT

With the arrival of the patient in the operating theatre, the problem of approach is not as a rule difficult. Orthodox incisions give conspicuously good access and are in reality time-saving. On this account transverse incisions, which can be so useful in civil practice, are best avoided and atypical methods of approach best discouraged. The position of the man at the time of wounding must be borne in mind, it is usually erect. Deductions about the track of the missile depend on this fact, and it is well to remember that the abdominal viscera are in very different positions with the patient supine on the table.

The position of the foreign body is of comparatively little importance, as its removal is not an object of laparotomy and its localization by X rays of secondary importance. The value of X rays in wounds of the abdomen has, in our view, been very exaggerated. Procedure at laparotomy is not, indeed, affected by the position of the foreign body on a film, the radiograph involves unnecessary disturbance to the patient in its taking and more waste of time than is justifiable from the equivocal results of its development. Antero-posterior and lateral films are required in cases of real doubt and the latter are notoriously unsatisfactory on the portable type of machine suitable for forward work.

**Anæsthesia**—Little space can be devoted to considerations of anæsthesia here, but certain principles of proved worth may be repeated—the reliability of intravenous premedication, the inadvisability of more than small doses of pentothal, the value of endotracheal methods, and the worth of gastric aspiration. This last measure may be useful before induction and the tube can be left in for post-operative suction where required. Bronchial aspiration may likewise be helpful before leaving the theatre.

Finally, it may be said that local anæsthesia, in our belief, has little place in the surgery of the abdominal wound and splanchnic block none at all. We have no experience of spinal anæsthesia, but the inevitable fall of blood-pressure accompanying it is obviously not in its favour.

**Associated Wounds**—It is clear from an analysis of results that the fate of the patient often turns on the nature of his associated wounds. These should, if possible, be dealt with before laparotomy or alternatively co-incidentally by a second surgeon. Wounds of the back or buttocks especially illustrate this point, as the turning required is highly undesirable at the end of an abdominal operation.

The term 'Associated Injuries' in *Table I* refers to major wounds, classed as priority 2 of themselves (fractures, vascular injuries, large flesh wounds demanding resuscitation on their own account). Coincident first priority wounds such as major amputations, penetrating wounds of the pleura, and fractures of the femur are included and account as always for a number of the disappointments of abdominal surgery in war. Coincident minor wounds present no difficulties and have even been treated by excision and primary suture over penicillin, with excellent results.

## THORACO-ABDOMINAL WOUNDS

The term 'thoraco-abdominal' has purposely been used in preference to 'abdomino-thoracic', as the majority of the cases reviewed had wounds of entry in the thorax and no wound of exit in the abdomen. The foreign body was lodged in the liver in many of these. Involvement of a solid viscus, such as this, is much less serious than a hollow viscus, and the fact that no laparotomy is required in many of them is much in the patient's favour.

Apart from the cases quoted, we have notes of 16 cases (12 right and 4 left) in which no operation was undertaken and the patient recovered. These wounds all involved the pleural cavity and liver or kidney (as judged by a clinical hæmoperitoneum, estimation of the wound track, radiograph, aspiration of bile, or hæmaturia). With the 59 cases treated operatively, they comprise a total of 75, with 27 deaths (36 per cent). This approximates very closely to the figure for abdominal wounds only and contrasts with the conclusions of Estcourt and others (1944), who regard thoraco-abdominal injuries in such an unfavourable light.

The accessibility of the upper abdomen through the diaphragm on the left side and the ease of splenectomy by this route have already been stressed elsewhere. If laparotomy is required after exploration of the chest, a Kocher's incision (on either side) has proved most useful. Nephrectomy has been carried out through it without difficulty. Similarly, a kidney has been delivered through a tear in the diaphragm and left, as the laceration of the upper pole was not severe enough to require nephrectomy. The avoidance of a laparotomy or lumbar approach to the kidney in this patient probably made his convalescence smoother.

Discussion of the thoracic part of these combined wounds does not come within the scope of this paper, but it is this rather than the abdominal wound which is most liable to give trouble afterwards. Routine post-operative aspiration and penicillin replacement is the method of choice, and there is no need for an intercostal catheter until or unless a frank empyema develops.

## WOUNDS OF THE LARGE GUT

Exteriorization of wounds of the large bowel has been the accepted practice to date and Ogilvie (1944) states that "simple closure of a wound of the colon, however small, is unwarranted, men have survived such an operation, but others have died who would still be alive had they fallen into the hands of a surgeon with less optimism and more sense. Injured segments must either be exteriorized or functionally excluded by proximal colostomy". Of 73 wounds of the large intestine (*Table IV*) 16 have been treated by suture with 5 deaths and 57 by exteriorization with 26 deaths. In the two groups appears to be a difference in the number of deaths of a more routine nature, is both simpler and often

There are, of course, exceptions to this statement, and complete division of the bowel, established intraperitoneal infection, and damage to the blood-supply, necessitating resection, may make an extra-peritoneal operation the wiser measure.

On the left side, on the other hand, wounds of the descending and pelvic colon lend themselves well to colostomy, and exteriorization has given good results. Those below this require functional excision. The change in consistency of the bowel contents and their higher infectivity on this side are reasons in its favour. It is likewise true that a left inguinal colostomy can functionally exclude a lesion below it whereas a cæcostomy cannot and provides partial diversion only. We have rarely found the latter of use. There is, in fact, no counterpart in the surgery of war wounds for the life-saving cæcostomy, relieving intestinal obstruction from growths in the colon.

None of the deaths in this series from 'peritonitis' has followed suture of a wound of the large gut, and thus, in our view, is not without significance. The principle of exteriorization in lesions of the large bowel is based on this danger and is understandable in civil surgery when the patients are as a rule elderly and dehydrated with the cachexia of an intestinal neoplasm. The fighting soldier, on the other hand, is the very opposite and would appear to be able to seal off his perforation once it has been sutured. The proximity of omentum to wrap round the ascending and transverse colon is also a point in favour of intraperitoneal repair on the right side.

Extraperitoneal wounds of the rectum are not considered here as they do not, by themselves, require laparotomy. They have not been included in the figures of abdominal wounds. Intraperitoneal wounds, on the other hand, require suture and perhaps inguinal colostomy.

### WOUNDS OF THE SMALL GUT

These are the commonest of abdominal injuries and the decision between suture and resection is not as a rule difficult. The latter naturally carries the higher mortality. Associated injuries in these cases are very important and there is a striking difference between the mortality of all abdominal wounds with and without them, reflected in respective figures of 42.6 per cent and 25.6 per cent. Gluteo-abdominal and spino-abdominal lesions are also much more serious than simple abdominal ones.

Eventration of the small gut has been met with on several occasions combined with transection of the prolapsed loops in three cases. Two of these survived. The following illustrates the type of injury well —

A man wounded by shell (H.E.) was seen at a F.D.S. 6 hours after injury. Some 18 in. of ileum was eventrated through a wound just above the right inguinal ligament and there had obviously been severe bleeding from the bowel and mesentery. Laparotomy after rapid resuscitation revealed multiple perforations of the small bowel with three complete transections. Two feet of ileum were resected and a wound of the intraperitoneal portion of the rectum sutured (without colostomy). The patient made a good recovery.

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Double-layered end-to-end anastomosis was done in this case in accordance with our usual practice. Perforations, on the other hand, seem to do well with single layered suture only—in contrast to the large gut, where we invariably employ two layers.

Drainage of the abdomen in these cases has little to recommend it, as blood, rather than intestinal contents, is usually found in the peritoneal cavity.

### WOUND OF THE GENITO-URINARY TRACT

Wounds of the kidney alone are less frequent than those associated with injuries of some other viscus. Simple lumbar nephrectomy, therefore, is not often required, but, when done, is usually followed by a smooth convalescence. As with the spleen, war wounds of the kidney present a clinical picture quite unlike the dramatic picture of the ruptured viscus in civilian life. Blood-clot (and not much of it) rather than free blood is the usual finding in the peritoneal or perinephric space and the operative procedure entailed is an easy one, not so with wounds of the hilum, which can provide technical difficulties, if only by reason of damage to the pedicle.

Delayed nephrectomy in wounds of the kidney has been required more than once, and experience has borne out the dictum of Gordon-Taylor that persistent hæmaturia after twenty-four hours is likely to end in nephrectomy. One such case illustrates this point well —

A man with a tiny penetrating shell wound of the right loin was seen at a Casualty Clearing Station 12 hours after injury. He had hæmaturia and no exploration of the wound was deemed advisable. On arrival at a General Hospital 48 hours after receipt of injury the hæmaturia was still marked but diminishing. Cystoscopy showed a copious bloody efflux from the right ureteric orifice and conservative treatment and slow blood transfusion were thought advisable. For a week there was microscopic hæmaturia only, but a sudden severe hæmaturia then occurred, lasting 12 hours. Another quiescent period followed with microscopic hæmaturia only, but three weeks after the initial injury severe bleeding recurred once more and nephrectomy had to be carried out. The convalescence was uneventful.

The lesion in the kidney was circular and approximately 2 cm. across, with a tiny metallic foreign body at the base of a pyramid.

Wounds of the bladder and urethra contrast strongly with those of the kidney, as they are usually complicated and often the result of buttock wounds also involving the anal canal or rectum. Combined injuries of the latter type do not, in our experience, do well. Wounds of the urethra, on the other hand, are easy to deal with in forward areas, the difficulty arising when repair is done at a Base hospital.

### WOUNDS OF THE ABDOMINAL WALL

It remains to observe of wounds of the abdominal wall that "things are not always what they seem." The most supposedly innocuous wounds of the abdominal wall may conceal the grossest of peritoneal mischief, the most ragged and severe being unassociated with intraperitoneal damage. On one occasion a metal fragment 3 in. long, projecting

in out of the abdominal wall, revealed after removal a tiny hole in the peritoneum beneath which was a coil of ileum presenting a second-degree burn. This had obviously been caused by the tip of the hot metal fragment, it required no treatment and the patient's post-operative progress was uneventful.

In conclusion, it may be stated that it has been our practice to drain the laparotomy wound where there has been gross soiling and to drain the peritoneum only when bile or faeces in large quantity has contaminated it.

### POST-OPERATIVE TREATMENT

The post-operative care of a man with a laparotomy for abdominal injury is governed primarily by the fact that he remains where he is for ten days or more after operation. Experience has shown the danger of moving him before the stitches are out, and the evolution of the present medical lay-out in the Field has been largely determined by a decision to hold first priority patients such as these for approximately this length of time.

Be it in the Field Dressing Station or Casualty Clearing Station, the patient remains until his general condition warrants evacuation and the abdomen can be fairly said to be quiescent.

Certain general principles are accepted as useful in the immediate post-operative period—venoclysis, gastric suction, and the administration of morphine. It must be remembered, however, that stereotyped methods, such as these, have their fallacies, and it is of the utmost importance to bear them in mind. The question of position is perhaps the first, and the danger of sitting patients up too soon after laparotomy should always be remembered. Likewise, careful handling in the theatre after operation, in transit to the ward, and in moving from the stretcher to the bed all repay the little trouble they involve.

The quantity of intravenous fluid given after operation is of the utmost importance and the danger of over-administration is particularly great in winter. A standard rate of 5 pints per day (2 plasma and 3 glucose-saline) has been our practice, and it is well to be cautious after the total has reached 15–18 pints. Many a patient, in fact, has been over-transfused into his grave by a surgeon in a state of 'ileus-phobia', complacent meanwhile in the fluid balance on a chart showing gastric suction and venoclysis figures. Better is it to pay heed to the rôles at the bases than be bound by figures and fluid charts. The table showing causes of death bears this point out well, pulmonary complications accounting for nearly half the total after "shock" and hæmorrhage are excluded. The nature of these pulmonary complications will be discussed later, but œdema figures prominently and venoclysis can often be blamed for that.

The value of sulphadiazine (6 g daily) in the intravenous drip has already been stressed by Ogilvie and others, and results, as yet unpublished, show it to be superior to penicillin in combating peritonitis. In view of the nature of the intestinal flora this is not of itself surprising.

Morphine (gr  $\frac{1}{2}$ ) four-hourly has always proved satisfactory as a sedative for the patient and his alimentary canal and it can usually be discontinued

as soon as the bowels act. This is rare before the fourth day, but it does not mean that an enema before this is always contra-indicated. It may indeed be a helpful measure in, for example, a patient with an injury of the small gut whose large bowel was loaded at the time of operation. The bowels may not have been opened for twenty-four hours or more before receipt of injury. An enema may likewise be useful as a preliminary measure before starting a rectal drip—a form of parenteral fluid administration the uses of which are too often forgotten. The ability of a patient to return the fluid instead of being forced to accept it, perhaps with a pulmonary system already waterlogged, is a point much in its favour.

The diet in the early stages, when continuous gastric suction is working, must be fluid, but fluids other than water should be given. Careful fluid charts have repeatedly shown that a pint or more of fluid per day is retained even with continuous suction. Nutrient fluids are therefore of use. Once the suction is discontinued the diet can be gradually augmented, and it has been our practice to give ascorbic acid (200 mg daily) as well, this is continued up to the time of evacuation.

Ideally evacuation should not be allowed until the laparotomy wound has healed, there is no evidence of residual infection, and the patient would be getting up if his other wounds permitted it. A rule of 10 days as a minimum period before evacuation is usually satisfactory, but many cases require retention for longer than this. Rodgers has stated that infection in the abdominal wound is an indication of infection in the peritoneal cavity, but this is not invariably the case. It may be truer to say that a soundly healed abdominal wound rarely means intraperitoneal trouble, whereas the converse is not so consistently the case.

Late complications such as the incidence of obstruction, faecal fistula, the difficulties of closure of colostomies of various types, and the problems of urethral repair in injuries of the genito-urinary tract do not come within the scope of this paper. They are mentioned because they account for a small mortality, which cannot be included in the figures quoted. They bear, in fact, on the mortality of abdominal wounds, the assessment of which is more difficult than is the mortality of abdominal operations. To prove that it decreases with experience and advances in the management of the battle casualty is far beyond our present domain.

### COMPLICATIONS

Table VII shows that more than 50 per cent of deaths occur from 'shock' or hæmorrhage within the first 48 hours, and it is clear that many of these are in reality mortal wounds, only brought to operation by the efficiency of Field Transfusion Units, stretcher bearers, and evacuating forward units. Mud, mule transport, and mountain terrain clearly diminish their number.

After this, the fate of the patient depends partly on the nature and multiplicity of his wounds and the interval between wounding and operation (Table V). Late deaths from systemic complications of associated wounds are significant but unimportant when contrasted, for example, with those from



# THE ABDOMINAL WOUND IN THE FIELD

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pulmonary causes These include bronchopneumonia, pulmonary oedema, and embolism, and in our experience are rarely of the 'post-anæsthetic' type met with in older patients of civilian practice. Atelectasis has occurred, but not commonly, and re-expansion has always followed without bronchoscopy. No case in this series has, in fact, shown a collapse that failed to re-expand, and it is noteworthy that we know of no case of lung abscess occurring after laparotomy for injury below the diaphragm. Subphrenic abscess is also conspicuous by its absence.

Post-operative complications in the abdomen are of a different nature and the absence of paralytic ileus in *Table VIII* is striking. This we attribute to the 'anti-ileus' regime mentioned, but it does not imply that silent distension of the abdomen has not often been seen. It occurs quite frequently, but when not due to peritonitis has not proved fatal in this series. Peritonitis, on the other hand, has occurred in 9 cases (3 without visceral repair), and in all these was evident at operation. Such

which so commonly becomes evident on the fifth to seventh day, when dilution has followed the initial blood-loss. Fresh blood, in this case, is infinitely better than the stored variety.

The administration of blood, however, both before and after operation must be undertaken with care, as reactions are common—rigors, anuria, and jaundice among them. The so-called 'transfusion kidney' has been seen with extra-abdominal wounds, but does not figure in this series. The 'crush syndrome' in the one death from this cause can fairly be ascribed to the associated wound, as the following account shows—

A man was admitted to a Field Dressing Station six hours after injury by falling masonry, resulting from a shell-burst on a farm house in which he was asleep. His right thigh and buttock were pinned under stone for approximately half an hour. On admission his abdomen was rigid and obviously full of blood, yet his blood-pressure was 145/90. The probability of a crush injury was entertained from the start, but so severe was the blood-loss into the peritoneum that one pint of blood seemed imperative after embarking on laparotomy. The

Table I—ABDOMINAL WOUNDS  
(151 cases, mortality 34 per cent)

	WITH ASSOCIATED INJURIES*		WITHOUT ASSOCIATED INJURIES	
	Alive	Dead	Alive	Dead
Single viscus	30	19	33	12
Two viscera	9	8	19	5
Multiple viscera	2	3	2	2
Without visceral injury	1	1	4	1
Total	42	31 (42.4 per cent)	58	20 (25.6 per cent)

Table II—THORACO-ABDOMINAL WOUNDS  
(59 cases, mortality 46 per cent)

	WITH ASSOCIATED INJURIES*		WITHOUT ASSOCIATED INJURIES	
	Alive	Dead	Alive	Dead
Left —				
Single viscus	1	1	4	2
Multiple viscera	3	6	4	3
Right —				
Single viscus	8	4	4	2
Multiple viscera	1	5	7	4
Total	13	16 (55.1 per cent)	19	11 (36.6 per cent)
Combined totals (Tables I and II)	55	47 (46.0 per cent)	77	31 (28.7 per cent)

TOTAL CASES, 210, MORTALITY, 37.1 per cent  
\* Associated injuries are only indicated when these injuries were themselves of second priority degree or greater

wounds are always late and the patient's circulation very poor and one of us (C. G. R.) has tried massive infusions (8 pints in 24 hours) of plasma in an attempt to keep these moribund cases alive. One of 3 cases survived, he had 16 pints in the first 48 hours and 5 pints daily for three days after that. Fluids other than plasma and glucose-saline have been employed in the treatment of some of these cases—hypertonic saline for the thoraco-abdominal with severe laceration of the lung, alkali for the patient with threatened anuria (2 per cent or 4 per cent sodium bicarbonate), blood for the anæmia

jejunum was found transected in two places and 18 in was resected with end-to-end anastomosis. On the following day the pulse-rate was 80 and the blood-pressure 180/140, but in spite of large doses of sodium bicarbonate orally and parenterally and 4.2 per cent sodium sulphate intravenously the urinary output was nil. Only 10 oz. were passed in all before death in uræmic coma on the fourth day. Autopsy showed no peritonitis and a sound anastomosis, but sections of the kidneys showed the changes typical of a crush syndrome. The common femoral artery was the only other noteworthy feature, showing a thrombus 3 in. above the site of crushing of the limb.



In this patient the need of blood for blood-loss had to be balanced against the possible danger of subsequent anuria, and it is clear that its administration achieved nothing but harm. The combination of circumstances, however, is a rare one and the dilemma not likely to recur in a similar series of cases.

### MORTALITY

An all-in mortality of 37 per cent in 210 cases is closely parallel to other larger series quoted elsewhere. It includes a number of cases in which 'shock' was

Table III—WOUNDS OF THE SMALL INTESTINE

(85 cases, mortality 36.4 per cent)

(With or without associated visceral or other injuries)

	Alive	Dead	Mortality per cent
Suture	41	16	28.5
Resection	14	15	51.7
Totals	54	31	36.4

Table IV—WOUNDS OF THE LARGE INTESTINE

(73 cases, mortality 42.4 per cent)

(With or without associated visceral or other injuries)

	Alive	Dead	Mortality per cent
Suture	11	5	31.2
Exteriorization	31	26	45.8
Totals	42	31	42.4

Table V—AVERAGE TIME FROM WOUNDING TO OPERATION

All cases	9.4 hours
Survivals (130)	7.9 hours
Deaths (78)	12.0 hours

Table VI—BUTTOCK WOUNDS  
(Involving viscera)

Total	Alive	Dead	Mortality per cent
28	15	15	46.4

Table VII—TIME ANALYSIS OF DEATHS

	Cases
0-12 hours after operation	27
12-24 hours after operation	13
24-48 hours after operation	14
48 hours and over	24
Total	78

Table VIII—CAUSES OF DEATH

	Cases
Shock and hæmorrhage (usual cause at less than 24 hours)	48
General peritonitis (including 3 cases without visceral repair)	9
Pulmonary œdema or bronchopneumonia	8
Pulmonary embolism	3
Crush syndrome	1
Cholæmia	1
Gas gangrene	2
Septicæmia	1
Hæmorrhage from iliac vessels	1
Cerebral abscess	1
Acute pancreatitis	1
Missed perforation	1
Unknown (27 days after liver wound)	1

the cause of death presumed after autopsy and one in which hepatic failure played an important part. This case was seen six hours after injury with a right-sided thoraco-abdominal lesion, the chest wound being 'sucking' and the pleural cavity containing at least two pints of blood. Rib resection (of fragmented rib only) revealed a large tear in the diaphragm with a severely lacerated liver below it. This was bleeding freely and a gauze pack was inserted in an endeavour to stop it. The peritoneal cavity contained much blood. The

pack was removed in 24 hours and the patient improved slowly for three weeks. He died at a Casualty Clearing Station just over one month from receipt of injury and autopsy failed to reveal the cause of death.

Disappointments, however, are commonest in the first twenty-four hours after operation, when the patient is described as dying from 'shock'. Only an elucidation of this mystery is likely, in our view, to make an appreciable difference to the all-in mortality of abdominal surgery in the Field. As long as the rejection rate is low (we have seen only 4 cases in which operation was not undertaken, as the patient was too ill for anaesthesia) the figures will always include a large number of desperate cases in which the outlook in the surgeon's judgement is hopeless from the start. The policy of "leaving a man in a dark corner in peace" is not in fact one we have had to adopt, as we have never been so pressed with first priority work that the occasion demanded or justified it. It would be pleasant, moreover, to hope that it never will.

### SUMMARY

1 'In ambulance' transfusions are very useful and should be more widely employed.

2 Intravenous morphine is more reliable than subcutaneous.

3 Auscultation of the abdomen is a very valuable diagnostic measure.

4 Radiographs are of little value in the management of the abdominal wound.

5 Thoraco-abdominal wounds are no graver than abdominal.

6 Exteriorization of wounds of the large gut is the method of choice only in the pelvic colon. The results of suture are better.

7 Pulmonary œdema is a real danger of excessive post-operative venoclysis. Fluid by the rectum is often as satisfactory and less dangerous.

8 Paralytic ileus is a rare complication of operations on abdominal wounds since the introduction of continuous gastric suction and chemotherapy.

9 Of 78 deaths in a series of 210 cases 48 occurred within 48 hours of operation.

10 An elucidation of the problem of 'shock' is the most likely road to improvement in the fatality-rate of abdominal wounds.

We are much indebted to the anaesthetists and men of our Field Surgical Units for their loyalty and co-operation and the Commanding Officers and staff of the many units, who have nursed our cases, for their collaboration. We also wish to thank the administrative officers, who made forward surgery possible, and Brigadiers Weddell, Edwards, and Stammers, the Consulting Surgeons, under whom we have worked. Their excellent advice and criticism has been an inspiration at all times.

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## THE TREATMENT OF CERVICAL COLLAR-STUD ABSCESSES WITH SKIN INVOLVEMENT

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WHEN a tuberculous collar-stud abscess has advanced so far that the overlying skin has become implicated, it is difficult to know how best to deal with the situation. The majority of my patients with tuberculous glands of the neck are sent to me by Tuberculosis Officers, the very fact that such cases are referred from a tuberculosis service suggests that conservative measures have failed. With few exceptions, the history reveals that patients with cervical skin involvement and discharging sinuses have been subjected to conservative operations,\* to wit aspiration, incision, or incision and scraping. Accumulated experience causes me to regard scraping as a pernicious practice, not divorced from the danger of disseminating tuberculosis and provoking such iron-like induration (no doubt due to combined trauma and the introduction of secondary infection) as to dismay even a seasoned dissector. It is my fervent hope that this procedure will be abandoned, and a number of Tuberculosis Officers with whom I work associate themselves with this plea.

**Material upon which this Paper is Based —** Since September, 1939, I have operated upon 686 patients suffering from tuberculous cervical adenitis, of these, 200 had collar-stud abscesses with skin involvement. The experience gained by studying

**The Relation of the Superficial Abscess to the Breaking-down Glands —**In approximately 25 per cent of cases the superficial abscess does not overlie the breaking-down glands that feed it,

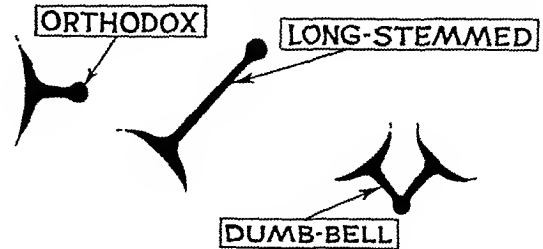


FIG 43 — Collar-stud abscess orthodox and variations

indeed, the factory and the storehouse may be as much as 6 or 8 in apart. If success is to attend the method of treatment I am advocating, it is fundamental to remove not only the storehouse, but also the factory and the tunnel which connects one with the other.

To postpone seeking the exact location of the breaking-down glands until the patient has been anaesthetized is to leave too much to chance. A proper pre-operative clinical examination of the



FIG 44 — Examples of long-stemmed collar-stud abscesses

the latter group of cases is the foundation of this paper. During the war there has been a considerable increase in the number of cases of tuberculous glands, and a much higher percentage of the type belonging to the category under discussion.

\* A number of Tuberculosis Officers read the draft of this paper. Several of them wish me to emphasize that they are not in favour of conservative operations: the patients had received treatment in the form of aspiration or incision and scraping before being referred to the tuberculosis service.

whole of the neck usually unmasks cases of long-stemmed collar-stud abscess (Fig 43), which are the ones requiring special technical consideration (see later). I note repeatedly that post-graduates and senior students often declare that long-stemmed collar-stud abscesses, of which Fig 44 shows typical examples, are a novelty to them. This is after they have either overlooked the causative lesion or failed to associate it with the abscess. Wherever a cervical abscess is situated, the breaking-down glands that feed it are most often located in the upper jugular

chain The incidence of the causative group of glands is shown graphically in *Fig 45*

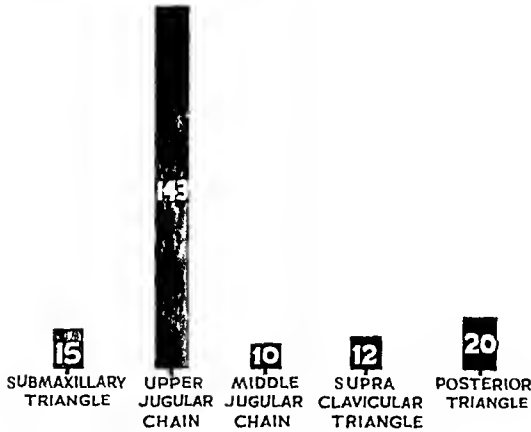


FIG 45—Showing the incidence of the site of the tuberculous glands which caused the abscess

### METHOD OF TREATMENT

**Evolution of the Method**—I came upon the open wound method of treating collar-stud cervical abscesses with skin involvement, or, to be more precise, the closed method of treating the open wounds that resulted from the complete extirpation of diseased tissue, by accident Towards the end of 1939, in a case of collar-stud abscess with particularly extensive skin involvement, I excised the unhealthy, inflamed skin and removed the underlying tuberculous glands, to find that the great vessels of the neck and a portion of the sternomastoid muscle were laid bare Heretofore, in the endeavour to close the wound (Bailey, 1932), I had undercut healthy skin, but on this occasion such a procedure was impracticable I, therefore, packed the wound, using gauze moistened with cod-liver oil, and applied a plaster cast in such a way as to immobilize the neck A fortnight later, when the plaster and the dressing were removed, I was surprised to find that the entire cavity, which previously had displayed the great vessels, was lined with healthy granulation tissue The cavity was re-packed and the neck immobilized once more, with the result that at the end of three weeks the crater had filled in (*Fig 46*) Accordingly, in keeping with current surgical practice, after proper preparation, I applied Thiersch skin-grafts to the bare area, but they failed to 'take' Later the Resident Surgical Officer repeated the grafting, but with no more success, it seemed as though the cod-liver oil which impregnated the granulation tissue militated against adherence of epithelium To my surprise, when I inspected the neck a fortnight after the second unsuccessful attempt at skin-grafting, the wound had almost healed and, what astonished me more, the scar was becoming narrow and linear

It was this case which emboldened me to excise unhealthy cervical skin deliberately and widely The results were so encouraging that I began to welcome a type of case which, up to that time, had caused me to groan, at least metaphorically It was not long before I adopted the following measures as a routine for these cases

### STANDARD TECHNIQUE

1 Excision of all unhealthy skin, including skin that at first sight appears healthy, but on close examination is found to be undermined and pathological on its under surface

2 Complete dissection of relevant diseased lymphatic glands When the sternomastoid interferes with their clear display, the muscle is divided and subsequently reunited

3 Haemostasis being rendered as perfect as possible, the cavity is sprinkled with pourable sulphanilamide powder and the whole crater filled with vaseline gauze As it enters the wound, powder is poured on to the gauze, which is never allowed to touch the skin It is important to employ correctly-made vaseline-gauze (Bailey and Pauline, 1944) If the product is too 'sloppy', vaseline continues to seep beneath the bandage and makes a mess which causes nursing disapproval, but, more important, the bandage tends to become displaced If it is too dry, the gauze sticks to the granulations, and bleeding and pain accompany the removal of the pack

4 The cavity having been packed moderately firmly and filled completely, but not overflowing, more sulphanilamide powder is sprinkled on to the



FIG 46—The original case three weeks after the operation Showing the cavity filled with healthy granulation tissue

surface and a piece of tulle gras laid over the mouth of the wound so as to overlap its edges

5 A viscopaste bandage is applied in such a way as to immobilize the neck It is of great importance to ensure that the bandage is applied in an efficient

manner, so that the patient, often a child (Fig 47) cannot displace it and expose any part of the wound

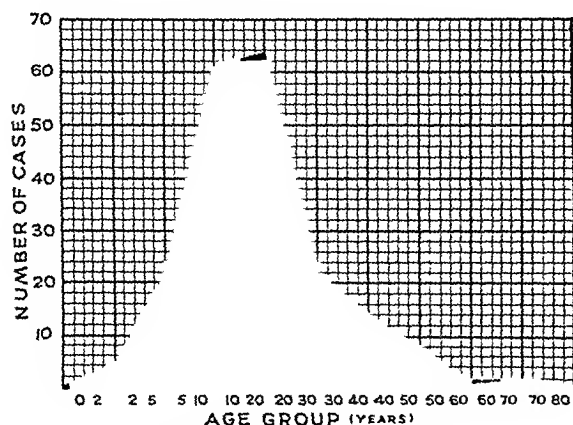


FIG 47—Age incidence of the series of 200 cases reviewed in this paper

**Other Details of Technique**—Tincture of metaphen has been used to prepare the skin. The hair of the parieto-occipital region having been shaved as necessary, the field of operation is isolated carefully (Fig 48). Because they tend to limit the space available, the clipping of towels to the skin edges has been discontinued in all operations of dissection of cervical glands. Throughout the series Coates' black cotton, No 24, has been

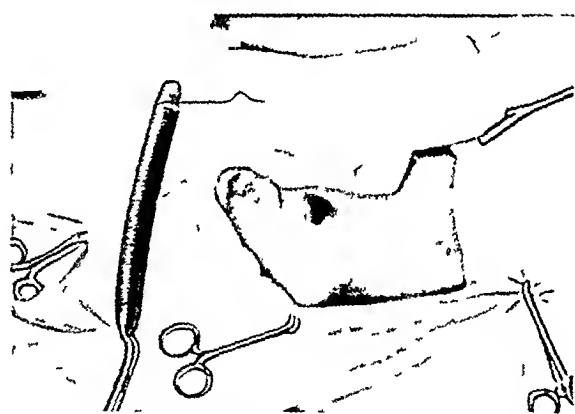


FIG 48—Showing the typical field of operation. The cotton ligature material is clipped to the towels

employed for ligature and suture material. Vaseline gauze was substituted for the cod-liver oil dressing after the fourteenth case. Early in the series (the fifth case) I substituted a viscopaste bandage for the plaster cast, and fixed the time of the changing of the dressing at the seventh day.

#### PRINCIPLES OF PARAMOUNT IMPORTANCE

It is not unusual to hear that a particular operative procedure claimed to be regularly and entirely satisfactory by the surgeon reporting it, is, in the hands of another, a failure, or at least not the unqualified success which was implied in the article. In such circumstances it often transpires that he who criticizes and doubts, either modified the

originator's instructions or, by insufficient study of the article, missed some detail which at first sight seemed unimportant. I therefore hasten to emphasize that unless three essential principles are observed, I am sure that the results of the method I am endeavouring to expound will prove unsatisfactory.

1 If diseased glands, or even a portion of a diseased gland, which fed the abscess are left behind, a chronic sinus will develop. In the case of a collar-stud abscess it is just as important to remove every vestige of relevant diseased tissue as to extirpate the entire thyroglossal tract in a case of a thyroglossal cyst or a thyroglossal fistula.

2 If, during the intervals of repacking, the viscopaste bandage becomes disarranged and the wound becomes exposed, secondary infection is likely to occur.

3 When the repacking of the wound is not undertaken in an operating theatre by a competent person who understands that the skin must be sterilized and that the new pack must be introduced with the same careful technique as at the operation, secondary infection will occur, consequently the result will not only be unsatisfactory, but the patient may develop serious symptoms.

In the only two instances where patients were evacuated to convalescent homes in which the principle of after-treatment was not understood, serious secondary infection ensued, the smooth apyrexial, painless post-operative course which I have come to regard as a *sine qua non* in these cases, was transformed into a great worry, and in one instance transfer to a fever hospital because of surgical scarlet fever was deemed expedient.

Rather than risk the after-treatment being relegated to persons unfamiliar with the method, it is far safer and in many instances quite practicable to send the patient home after a week or a fortnight. On many occasions I have followed this procedure, and the patient has attended once a week for the dressing to be changed in the operating theatre by someone who understands the simple, but essential, technique of repacking and bandaging. Several of my Sisters take a pride in this work, and have become so skilful that it may well be that my excellent results are due to the part they have played. It is also desirable to record that not in one instance has it been necessary to administer any form of anæsthetic or premedication for removal of the dressing and repacking the wound.

#### VARIATIONS OF OPERATIVE TECHNIQUE TO SUIT SPECIAL CIRCUMSTANCES

In order to gain access to the diseased lymphatic glands, the standard operative procedure is to find the opening in the deep fascia (Fig 49) through which the pus escaped. The abscess cavity is lined by Volkmann's membrane, which usually prevents the small hole from being seen, consequently the wall must be probed, but probed lightly, otherwise a 'false passage' may result. The opening having been found and enlarged appropriately, the next step is to ascertain by sight or touch the extent of the diseased glands that require extirpation. Often the gap left by the excision of the skin affords excellent exposure and, with suitable retraction, allows the necessary dissection to be undertaken.

When this is not the case, there should be no hesitation in making a suitable skin incision radiating from the original crater. In making the appropriate

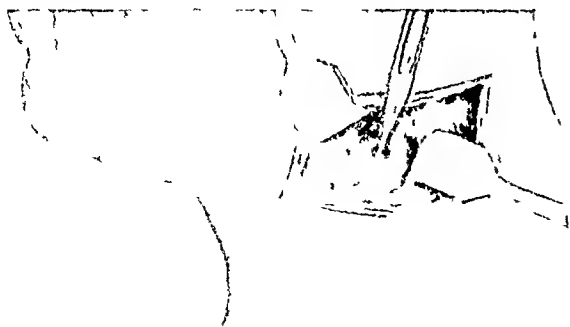
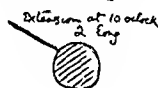


FIG 49—Seeking the opening in the deep fascia

extension, which I depict in the notes of the operation thus



the surgeon must take

Langer's (1861) lines into consideration (Fig 50)

As I have stated earlier in this article, if the sternomastoid muscle is in the way I always divide it. When the glands have been removed, the

skin over the collar-stud abscess, together with the walls of the abscess cavity, is excised. When this has been carried out and the opening in the deep fascia has been enlarged, usually it is found that the cavity caused by the extirpation of the glands communicates without hindrance with the cavity created by the abscess, and that all the relevant diseased glands have been removed. Occasionally, at this juncture, there is revealed a diseased gland or glands which were inaccessible through the incision, but which can be displayed and removed through the excised area. The operation is concluded by closing the skin incision with sutures, and packing the entire cavity by way of the area left by the skin excision (Fig 53, V, W).

**Dumb-bell Collar-stud Abscess**—In 7 examples of this particularly perplexing problem I have excised the unhealthy skin over each abscess to discover that there is but one group of tuberculous glands feeding both abscesses (see Fig 43), and that this is situated beneath the isthmus between the craters. Usually under the isthmus of healthy skin lies the sternomastoid. By making an incision across the isthmus (and, if it intervenes, through the sternomastoid) perfect access to the diseased glands has been obtained. As can be seen in Fig 53, X, the isthmus is repaired by sutures. Both cavities, and the tunnel which connects them, are filled with packing. These examples of double skin loss have healed in a remarkably satisfactory manner.

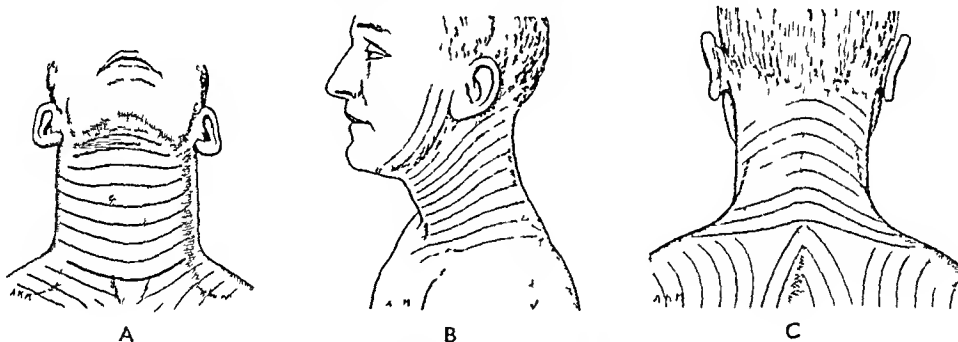


FIG 50—Langer's lines cervical region

incision in the skin is closed with sutures as far as the mouth of the crater and the wound is packed in the usual manner. Examples of the procedure are depicted in Fig 53, S, T, U.

**When the Stem of the Collar-stud is Long**—

In about 10 per cent of cases the superficial abscess is situated at a considerable distance from the tuberculous glands which feed it. The most common variety of long-stemmed collar-stud abscess is the result of pus tracking from breaking-down glands of the upper jugular chain and pointing in the lower third of the neck (See Fig 44). The second most common variety is when the pus from a similarly placed mass of glands tracks behind the sternomastoid muscle to point in the posterior triangle. In cases of long-stemmed collar-stud abscess I proceed to dissect out the diseased glands through a suitable transverse or oblique incision made directly over them. After this dissection has been completed, but before the incision is closed, the involved

## THE HEALING OF OPEN WOUNDS OF THE NECK, WITH SPECIAL REFERENCE TO LANGER'S LINES

Especially when studying my early cases, i.e., before repetition made several phenomena commonplace, I marvelled at the rapidity and regularity with which large craters in the neck filled in. Fig 51 shows a weekly photographic record of an average case. Again, I found, and still find, it difficult to understand how granulating areas, with a skin deficiency of as much as 5 in.  $\times$  3½ in. and averaging in the series 3.8 sq. in., become epithelialized without skin-grafting. Other unexpected pleasures were to observe that more often than not the resulting scars are not unsightly and are often linear (Bailey, 1942).

So utterly different were these findings from anything I had seen and learned in my long association with cervical surgery that I expected, and received, overwhelming scepticism on my testimony.

It was on account of this disbelief that I determined to obtain photographic proof (*Fig 53*) Other arrangements being impossible, the problem of obtaining necessary data concerning the crater was solved by taking the photographs, at the time of the first dressing, myself To accomplish this was

interest in this hypothesis I submitted a number of the photographs to Mr Cox, who affirmed that the scars followed Langer's lines, upon which he (Mr Cox) had been working Mr Cox was particularly impressed with the case of F W (*Fig 52*) where the scar in the upper part shows the change of

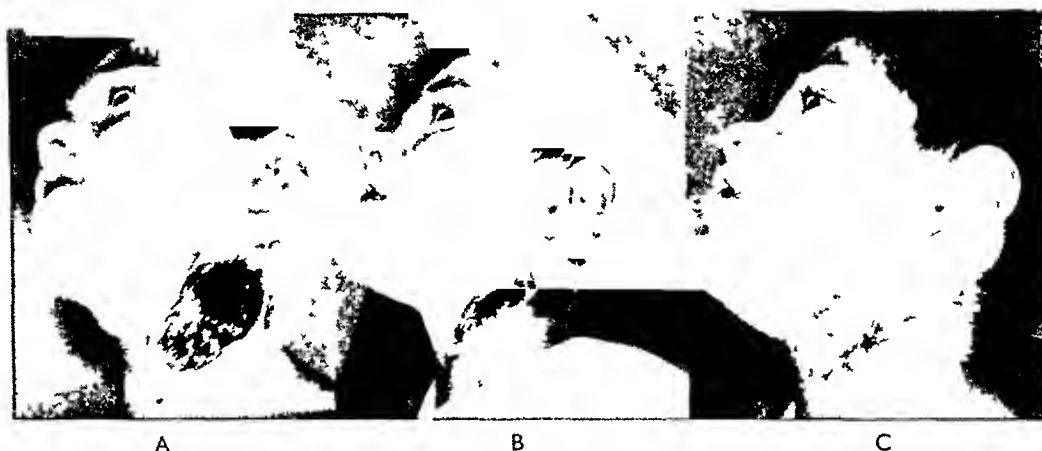


FIG 51—Showing the rate of healing after operation A, 1 week, B, 2 weeks, C, 3 weeks

merely a matter of personal effort, but to secure the photographs of the end-results was not so stereotyped, and difficulties were multiplied by many of the patients being evacuated, and not a few entering the Services It is most disappointing to me that some of the best photographs of open wounds cannot be utilized because the end-results, which are known to be good, are not photographically available

direction and runs horizontally I consulted Langer's article, written in 1861, to find beautifully executed woodcuts which would do credit to a well-produced modern publication, and there to learn that there is nothing new under the sun—that Dupuytren and Malgaigne had demonstrated that when the skin is punctured with a round instrument it leaves a slit, and not a round hole After all, what



FIG 52—The case of F W A, The patient had been treated by repeated aspiration, and a very large area of skin was involved B, After dissection of the diseased tissues a skin deficiency of 4 in x 3 in resulted C, The scar five months later

However, I feel that there is here reproduced sufficient photographic proof to convince anyone that these large cervical craters heal most satisfactorily, which is what I set out to do

Early on, when reflecting how a round hole could give rise to a linear scar, I turned to Kocher's *Operative Surgery* (1911), and refreshed my mind on his pictures of Langer's lines I noted that many of the cervical scars were in keeping with these lines It was the paper by Cox (1941) in the *BRITISH JOURNAL OF SURGERY* which awoke in me a real

is my contribution?—merely magnified confirmation of cutaneous experiments carried out by these bygone master surgeons

### END-RESULTS

While numbers of the patients have been under my observation intermittently until they were rehabilitated, it was thought desirable to have a fresh review of the end-results conducted by someone else Mr John East undertook this task, and

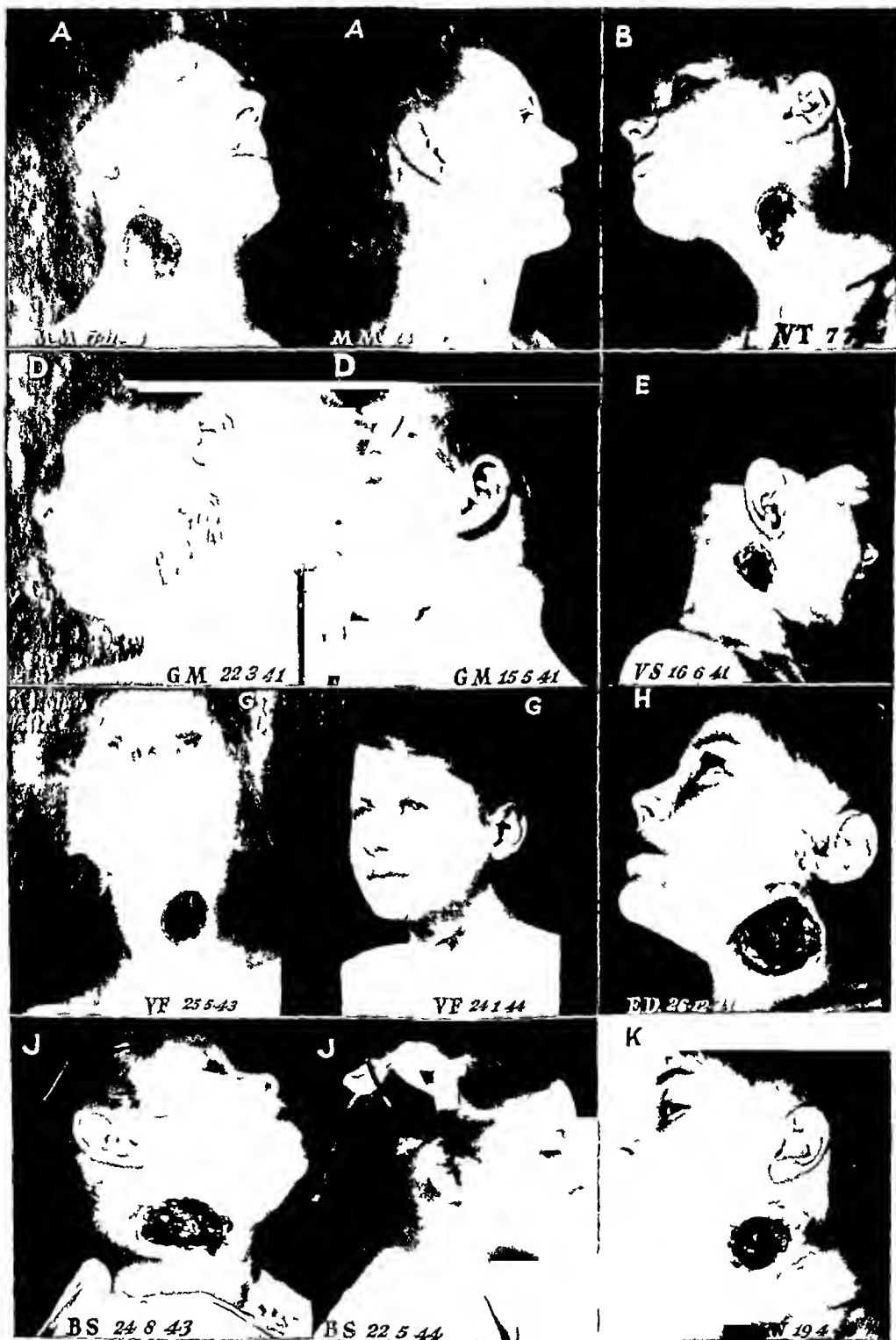


FIG 53—Typical examples of tuberculous collar-stud abscesses with skin involvement



# CERVICAL COLLAR-STUD ABSCESS



FIG 53 (contd) —In every instance the first photograph was taken when the wound was unpacked a week after the operation

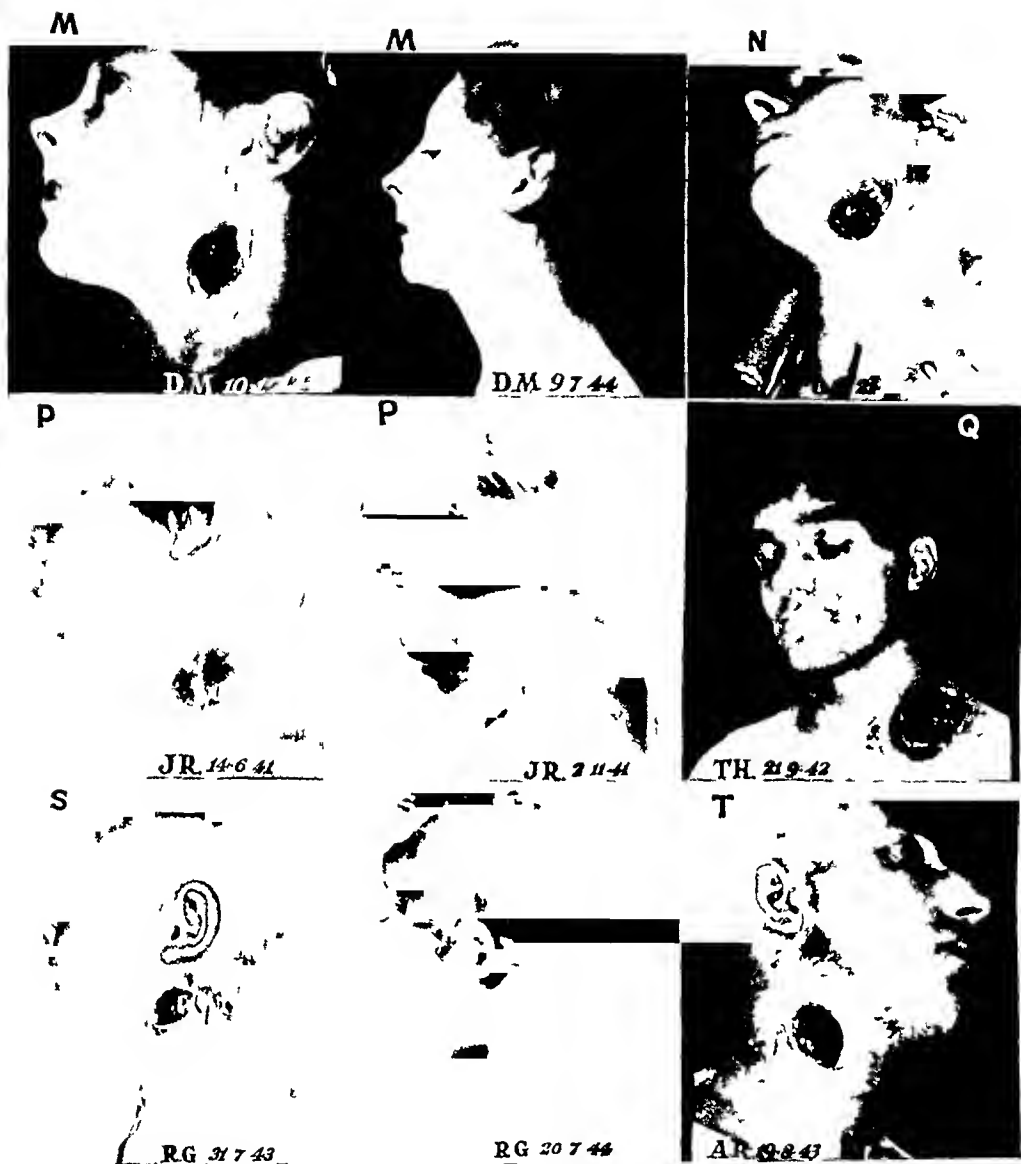


FIG 53 (contd)—The second photograph shows the scar which resulted

# CERVICAL COLLAR-STUD ABSCESS

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I am greatly indebted to him for the time and trouble he has expended in this direction. All who have tried it will confirm that to get together any large series of cases for the purpose of a follow-up presents difficulties, a proportion of patients are only too willing to co-operate, but there are others who will not put themselves to any inconvenience. When it is taken into consideration that this follow-up was undertaken during the V1 bombardment of "Southern England", it will be realized that it required more than ordinary perseverance on the part of the reviewer to make individual arrangements for each patient to come up to be seen. Mr East personally examined 111 cases for the purpose of this fresh review. I was able myself to interview 7 patients who, for one reason or another, could not get to Mr East's clinic, so out of 200 cases, 118\* were re-examined for this check-up.

The average period between the time of the operation and the time of this review was 98 weeks.

Improvement in general health	111 cases
Recurrence of tuberculous glands (all remedied)	3 cases
Absence from school (average period)	31 weeks
Absence from work (average period)	16 weeks

**Scars**—The average length was 2½ in. Most of the scars were linear or fusiform in shape. All

\* This does not mean that the remaining 82 patients were not followed up, on the contrary, most of them were examined repeatedly, but they were not available for this particular check-up.

the patients were examined in a brilliantly illuminated room and the scars (in 9 cases both sides of the neck were operated upon) were categorized as follows—

- a Keloid, 34 cases
- b Noticeable, i.e., could be seen at a distance of over 5 ft, 41 cases
- c Somewhat noticeable, i.e., could be seen only at a distance of 5 ft or under, 36 cases
- d Unnoticeable, i.e., could not be seen at a distance of 5 ft, 34 cases

It should be noted that all the so-called keloids were seen in patients who had been operated upon comparatively recently. In many of them the hypertrophy will no doubt disappear spontaneously. In one case the ugly scar was excised and the edges of the skin approximated with sutures. The result is satisfactory.

In this research I owe much to the inspiration and help of others, but limitations of space have prevented me from making detailed acknowledgment.

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## THE PATHOLOGY OF COLLOID AND NODULAR CHANGE IN THE THYROID GLAND AND ITS APPLICATION TO THE SURGERY OF NODULAR GOITRES†

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### INTRODUCTION

Toxic nodular goitre (secondary thyrotoxicosis) is a disease of the elderly, and, unlike Graves' disease (primary thyrotoxicosis), its histological features are not clear cut or constant. The characteristic histological feature of primary thyrotoxicosis is an epithelial hyperplasia fairly uniform throughout the gland, whereas in toxic nodular goitre the hyperplastic epithelium is limited to localized areas and its significance as a consistent indication of thyrotoxicosis is doubtful (Martin, 1940). Further, in primary thyrotoxicosis, the clinical severity bears a definite relation to the histological changes, and the pathologist can report with some accuracy on the severity of the condition, such is not the case with toxic nodular goitre (Plummer, 1913, Wilson, 1914, Edelman and Aschner, 1928). The difficulty is mainly due to the diverse histological appearances found in nodular goitres and the lack of any which

are constantly associated with all degrees of clinical thyrotoxicosis. Authorities such as Wegelin, Merke, and Josselin de Jong (quoted by Hellwig, 1939) go so far as to deny that histological examination can distinguish a toxic from a non-toxic nodular goitre, hence it is not surprising that clinician and histologist should often differ over cases of toxic nodular goitre.

In order to ascertain if the histological changes in nodular goitres, whether clinically toxic or not, are essentially due to nodule formation, with its consequent disorganization of the glands, a series of thyroids from non-thyrotoxic individuals of the same age-period as that in which toxic nodular goitres occur has been examined. In this material it is possible to compare the histological changes associated with age and non-thyrotoxic nodules with the changes in toxic and non-toxic nodular goitres.

The results of this study, combined with a consideration of the basic pathology of colloid and nodular change in the thyroid, provide points of practical importance in the surgery of nodular goitres.

† This work was partly carried out during the tenure (interrupted by the war) of a Leverhulme Research Scholarship of the Royal College of Physicians.

## MATERIAL

One hundred thyroids were examined from post-mortem subjects over 45 years of age in whom, so far as was known, there had been no clinical evidence of thyrotoxicosis. No thyroid was included from a subject in whom death was due to heart failure which might have been of thyrotoxic origin. The principal causes of death included cancer, vascular accidents, multiple injuries, infective states, and post-operative death.

The thyroids were removed, weighed, fixed, and then sliced for naked-eye inspection of the cut surfaces and selection of histological material. Nodules of  $\frac{1}{4}$ -in diameter or more, readily visible to the naked eye, were considered as significant. In many cases the presence of nodules was not revealed by external examination, but only when the gland was cut into slices. Particular attention was paid to this point.

## RESULTS

By the naked-eye and histological examination it was possible to classify the hundred thyroids examined as follows —

Type	Number	Average Weight
Average normal	26	25.7 g
Atrophic	15	16.3 g
Colloid		
a Diffuse colloid	30	28.8 g
b Nodular colloid	29	44.4 g

**Atrophic Thyroids**—Fifteen small and shrunken thyroids were found. This is not more than might be expected in a series from elderly subjects, some of whom were enfeebled by chronic diseases.

**Colloid Thyroids**—There were 59 colloid thyroids which were subdivided into (a) Those in which there was diffuse colloid change only, and (b) Those in which nodules were also present.

**a Diffuse Colloid Thyroids**—There were 30 diffuse colloid thyroids with an average weight of 28.8 g. They were not enlarged or asymmetrical, and although colloid change was suspected from the appearance of the cut surfaces it remained to be proved by histological examination.

**b Nodular Colloid Thyroids**—There were 29 colloid thyroids in which nodular change had occurred. Their average weight was 44.4 g.

It is noteworthy that in only 7 of these were the nodules detected by external examination, in the remaining 22 the nodules were only found on examining slices of the gland, although some of the nodules were  $\frac{3}{4}$  in in diameter and most of them had degenerated (Fig 54).

It is with these 59 colloid thyroids, with and without nodular change, that this study is concerned.

It will be convenient to compare the results of this investigation with similar studies before discussing the pathological aspects of colloid and nodular change in the thyroid. Jaffe (1930), Rice (1932), Nolan (1938), and Schlesinger et al (1938) all found that colloid and nodular changes in the thyroid became more frequent with advancing age. The actual incidence of these changes varied according to race and locality of the surveys, being highest in areas of endemic goitre, such as Switzerland and

parts of America, where colloid changes in the thyroid are almost universal. In the present series from East Anglia, where endemic goitre is not unduly prevalent, 59 per cent of thyroids from the over 45 age-group showed diffuse colloid and nodular changes.

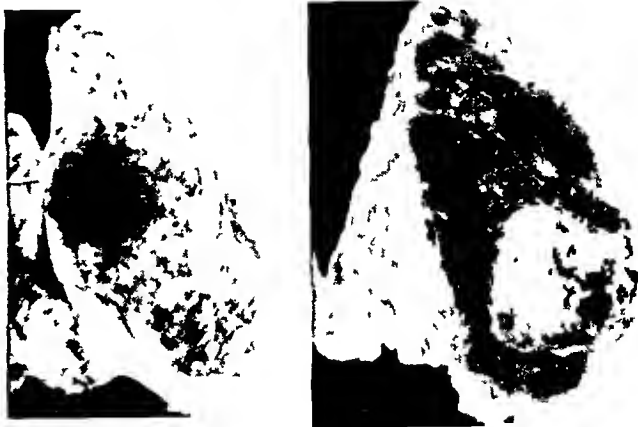


FIG 54—Photographs of cross-sections of thyroid lobes showing degenerate nodules which were not detected by external inspection and palpation (Natural size)

## PATHOLOGY

**Colloid Change in the Thyroid**—This can be ascribed in general to either (a) past iodine deficiency, or (b) simple increase in colloid storage. The ultimate histological pictures from either cause are similar.

**a Iodine Deficiency**—Marine (1923) first described a physiological cycle in the normal thyroid whereby recurrent phases of activity, associated with epithelial hyperplasia, alternated with a resting or colloid state. If absolute or relative iodine deficiency occurred, however, an initial epithelial hyperplasia was followed by permanent and excessive colloid storage termed 'hyperinvolvement'. This caused the thyroid to enlarge permanently and become a simple colloid goitre.

**b Increased Colloid Storage**—This process is probably not associated with iodine deficiency but with a decreased demand for thyroxine, hence the condition is not uncommon among elderly persons whose bodily and endocrine functions are waning. Thyroids in which there is increased colloid storage are seldom enlarged or asymmetrical and do not deserve the title of 'goitres'. There is only a difference of degree between the histological appearance of a true colloid goitre and a thyroid with increased colloid storage: both have large irregular acini, lined by low flattened epithelium and filled with deep-staining colloid, and there is little intervening stroma. Thus it is not always possible to be certain whether a colloid thyroid is the result of past iodine deficiency or of simple increase in colloid storage—although the larger and heavier the gland, the more likely is iodine deficiency to have been the cause. The 30 diffuse colloid thyroids in the present study were not enlarged or asymmetrical and their average weight of 28.8 g was within normal

limits. This suggested that the colloid changes were simply due to increased storage. Of the 29 nodular colloid thyroids, 7 exceeded 60 g in weight and were almost certainly the result of past iodine deficiency, while the remaining 22 which were not enlarged or asymmetrical, despite the presence of nodules, were more probably caused by increased colloid storage.

**Nodule Formation**—The formation and subsequent degeneration of nodules as an ageing process seems to be an inherent and probably universal property of colloid thyroids. It had already occurred in 29 out of 59 colloid thyroids in the present series. The exact mode of nodule formation is still uncertain and this study affords no evidence on the matter. The work of Marine (1923) has suggested that nodules result from local aberrations in the physiological cycle of hyperplasia and involution, and this is now generally accepted (Dunhill, 1930, W. Boyd, 1932, A. M. Boyd, 1938). Nevertheless, whatever views are held regarding the nature of nodules, it is evident that there is an inherent tendency for their production throughout the entire substance of a colloid thyroid. They cannot be incriminated as the cause of secondary thyrotoxicosis because they also occur in simple non-toxic goitres, and, as this study has shown, in the symptomless thyroids of elderly persons.

**Nodular Degeneration**—The nodules formed in a colloid thyroid frequently undergo degenerative changes, the various forms and stages of which can be followed histologically and were observed in the present study.

The large colloid-distended acini of the nodules may rupture and coalesce, thus forming even larger colloid lakes. Haemorrhage often occurs into the lakes from vessels running in the ruptured acinar walls and this still further distends and disorganizes affected areas. Compression and atrophy of surrounding thyroid substance at first gives rise to a pseudocapsule, but this in time becomes fibrotic, while liquefaction, clotting, organization, or patchy calcification may ensue in the mixture of blood, epithelial debris, and colloid contained within the nodule.

It is clear that with such processes at work many stages and forms of degeneration may be seen in the same or different nodular colloid thyroids, hence the histological appearances are inevitably variable and complex. No useful purpose would be served by giving in detail such protean histological changes as similarly occurred in the nodular colloid thyroids of this series. It is, however, significant that they did not differ materially from those seen in non-toxic nodular goitres or in toxic nodular goitres associated with mild or moderate clinical thyrotoxicosis.

It must be emphasized, however, that none of the nodular thyroids of this series bore a histological resemblance to a toxic nodular goitre associated with severe clinical disease. Such severe toxic goitres can be recognized histologically by their notable epithelial hyperplasia and, in general, be successfully correlated with the clinical state. It is the toxic nodular goitres associated with mild or moderate thyrotoxicosis which frequently cannot be distinguished histologically from non-toxic nodular goitres, and it is with the appearances of this type

that those of the nodular glands in this series coincided.

**Discussion of Histological Appearances**—The histological similarity existing between nodular thyroids from elderly subjects, non-toxic nodular goitres, and toxic nodular goitres associated with mild or moderate clinical thyrotoxicosis can be explained on two main grounds: first, by the presence of nodules and degenerative changes, and secondly, by the significance of areas of hyperplastic thyroid epithelium in the gland substance.

**1 Effect of Nodules and Degenerative Changes**—These changes are common to the three types of thyroid under consideration, and, having once occurred, they dominate the histological picture and may mask or perhaps prevent the occurrence of other changes peculiar to thyrotoxicosis.

The fundamental stimulus of thyrotoxicosis probably lies outside the thyroid, but it is the ability of the thyroid to react to this stimulus which determines the histological appearances as well as the patient's symptoms.

Thus in primary thyrotoxicosis the previously normal thyroid reacts by a diffuse epithelial hyperplasia, but in toxic nodular goitre the thyroid is already the seat of so much colloid, nodular, and degenerative change that the added thyrotoxic process may fail to provoke recognizable alterations. The strength of the thyrotoxic stimulus may well be significant. If it be sufficiently powerful then, as stated above, it will produce recognizable histological appearances in the nodular thyroid, but if it be of lesser degree it may be insufficient to cause either marked clinical effects or additional histological changes.

**2 Significance of Hyperplastic Thyroid Epithelium**—Localized areas of epithelial hyperplasia are common to all three types of thyroid under discussion and therefore cannot be accepted as reliable evidence of thyrotoxicosis. Epithelial hyperplasia can occur in the thyroid from a multitude of causes, of which thyrotoxicosis is but one and nodule formation another. The areas of hyperplastic epithelium in the substance of a non-toxic nodular thyroid probably represent the efforts of a gland, partially disorganized by nodules, to maintain adequate function; they are thus analogous to the compensatory hyperplasia which ensues in a thyroid residue after partial thyroidectomy. In a toxic nodular goitre the same compensatory hyperplasia occurs, but in addition there may be superadded some which is due to thyrotoxicosis. As already stated severe thyrotoxicosis produces a degree of hyperplasia which is greater than could be accounted for by simple compensation for nodules, but mild or moderate thyrotoxicosis may cause little or none in addition.

It seems, therefore, that the basic histological changes in the three types of thyroid are due to nodule formation and degeneration. A histologist cannot be expected to identify each of the three types, although he can recognize changes in nodular thyroids which are associated with severe clinical thyrotoxicosis.

## SUMMARY

The outcome of this study and discussion of the pathology of colloid and nodular change in the thyroid may be summed up as follows—

Colloid change is common in the thyroids of persons over the age of 45 years, with nodule formation and degeneration as inherent and almost universal accompaniments of increasing age.

Nodules often occur within the gland substance and cannot always be detected by external examination alone.

The histological appearances of nodular colloid thyroids from elderly non-thyrotoxic individuals are indistinguishable from those of non-toxic nodular goitres and the milder toxic nodular goitres. Localized areas of hyperplastic epithelium in a nodular thyroid or a nodular goitre cannot be accepted as reliable evidence of secondary thyrotoxicosis.

### APPLICATION TO THE SURGERY OF NODULAR GOITRE

The above results have a direct bearing upon the surgical treatment of nodular goitre and of toxic nodular goitre in particular, for this disease is characterized by the serious complications of cardiac failure and auricular fibrillation which experience has shown can only be prevented or cured by adequate thyroidectomy.

The unfortunately inaccurate and persistent description of thyroid nodules as 'toxic adenomata' has for too long focused attention upon the nodules and encouraged operations such as 'dissection-enucleation' and hemithyroidectomy for nodular goitres.

These operations are illogical and even dangerous for two main reasons: first, the whole thyroid gland is affected in secondary thyrotoxicosis and not the nodules alone, hence their local removal cannot be adequate treatment; second, the local removal of nodules, though it may relieve pressure symptoms, cannot prevent other nodules from forming in the thyroid residue. Patients who have undergone one or more such piecemeal operations without protection from recurrent thyrotoxicosis, further nodule formation, or subsequent thyrotoxic heart failure, are still regrettably common. Even if a nodular goitre is thought to be non-toxic at the time of operation its liability to future thyrotoxic change cannot be excluded and certainly cannot be prevented by partial removal.

The observation in this study that only a small minority of nodules presented at the gland surface is an additional reason against minor thyroid surgery. The presence of even one external nodule should indicate to the surgeon that others which he cannot detect are probably present, hence he should not be tempted to remove locally the one which he can see.

It must be admitted that true benign 'fœtal' adenomata do occur in the thyroid and that they are usually solitary (Boyd, 1928), although not invariably so (MacLay, 1943). On clinical grounds their nature can only be suspected (Means, 1937), the proof

depends upon histological confirmation and, because no surgeon can be certain that a nodule is in fact solitary, their occasional occurrence should not justify local removal.

There are thus very cogent reasons for advising as total a thyroidectomy as possible in all cases of nodular goitre which come to operation, whether for clinical thyrotoxicosis, relief of pressure symptoms, or for cosmetic reasons. The risk of hypothyroidism is not large in later life, and even should it occur, substitution therapy with thyroid extract is preferable to thyrotoxic heart failure or further operations.

This plea for massive thyroidectomy in cases of nodular goitre is naturally subject to operative safeguards for preservation of the recurrent laryngeal nerves and adequate parathyroid tissues. Clearly no thyroidectomy can be absolutely total without needlessly imperilling these important structures.

It may not be out of place to consider briefly the policy to be adopted towards nodular goitres in middle-age or elderly patients who have neither pressure symptoms nor thyrotoxicosis. Although such complications are always liable to occur, it would clearly be wrong to advise removal of every nodular goitre as an insurance against future trouble. Much will depend upon individual factors in each case, but in general it is reasonable to keep such patients under observation and only to advise thyroidectomy at the first indication of thyrotoxic or pressure symptoms.

Finally, the lack of reliable histological evidence of thyrotoxicosis in the less severe types of toxic nodular goitre means that the diagnosis must often rest entirely on clinical findings, and that confirmation, if needed, should be sought in the patient's improvement after adequate thyroidectomy.

As always in medicine or surgery, sound pathological principles are the basis of good treatment, and they should apply with perhaps special emphasis to the surgery of nodular goitres.

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## THE LATE TREATMENT OF DORSAL INJURIES OF THE HAND ASSOCIATED WITH LOSS OF SKIN

By J B CUTHBERT

PLASTIC SURGEON TO AN E M S PLASTIC SURGERY UNIT

DORSAL injuries of the hand are seen with considerable frequency in war-time and can produce very severe disablement. The injuries are often complex, and the causation of the various deformities and limitations of movement in the healed condition

### I SKIN LOSS ON DORSUM OF HAND

The deformities produced by loss of skin alone from the dorsum of the hand are seen in avulsion injuries, but more commonly in burns. If such

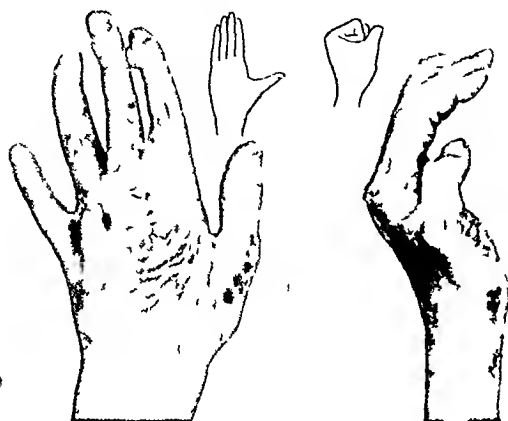


FIG 55—Case 1 Healed burn of dorsum of hand showing scarring and limitation of flexion

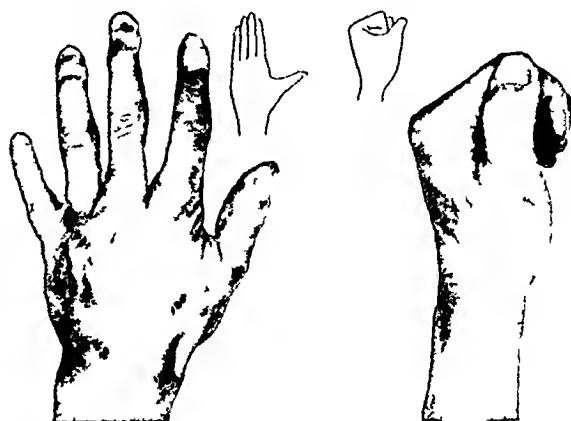


FIG 56—Same case Result after scar excision mobilization of joints, and skin-grafting One-stage operation

is not always obvious on cursory examination. If the fullest possible return of function is hoped for, it is desirable, at any rate in the more complicated cases, to plan in detail the various stages of the reconstruction before operative treatment is commenced.

Injuries are allowed to heal by natural edge epithelialization and scar contracture, the basic deformity is narrowing of the transverse arch of the hand with adduction of the metacarpals, in particular that of

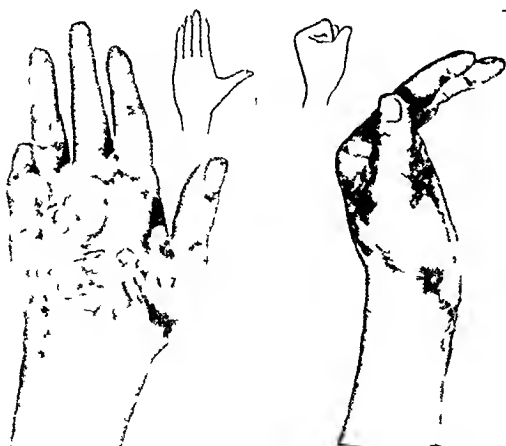


FIG 57—Case 2 Healed burn of dorsum of hand, showing scarring and limitation of flexion

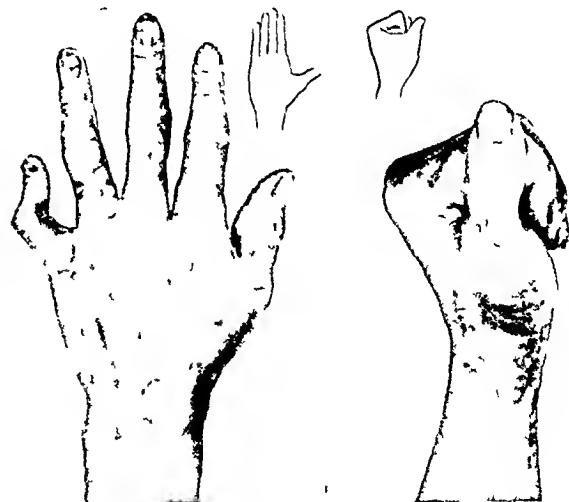


FIG 58—Same case Result after scar excision, mobilization of joints, and skin grafting One stage operation

The following cases are presented as illustrative of some of the types of planned reconstruction which may be adopted in the late treatment of dorsal injuries of the hand associated with loss of skin.

The adduction of the thumb is accompanied by a lateral rotation of the thumb about its long axis, the rotation taking place principally at the carpometacarpal joint.

## DORSAL INJURIES OF THE HAND

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The metacarpophalangeal joints are more or less immobilized, commonly in extension or even in hyperextension with some degree of subluxation of the metacarpal heads. The interphalangeal joints are often pulled into flexion as a result of the hyperextension of the metacarpophalangeal joints caused by involvement of the extensor tendons on the dorsum of the hand in contracting scar, and the consequent "stretch reflex" action of the long flexor muscles of the fingers. In other cases the interphalangeal joints may be held in the position of extension and show a few degrees of active flexion.

If healing takes place rapidly, the hand, although crippled, is not irreparably damaged, and may be restored to function approaching normal by radical scar excision and skin-grafting coupled with capsulotomies to free joint contractures. If healing is

### 2 DORSAL SKIN LOSS WITH DESTRUCTION OF EXTENSOR TENDONS

*a Destruction of Extensor Tendons on the Dorsum of the Hand*—In the healed condition cases in this group show dorsal scarring of the hand with loss of extension of the affected digits. Active extension at the metacarpophalangeal and sometimes at the interphalangeal joints is absent. Active and passive flexion of the metacarpophalangeal joints is also impossible where the distal stump of the divided extensor tendon is firmly anchored in the scarring on the dorsum of the hand. The injury may thus render both flexion and extension at the metacarpophalangeal joint impossible. A full range of active extension at the interphalangeal joints may be preserved in cases where the

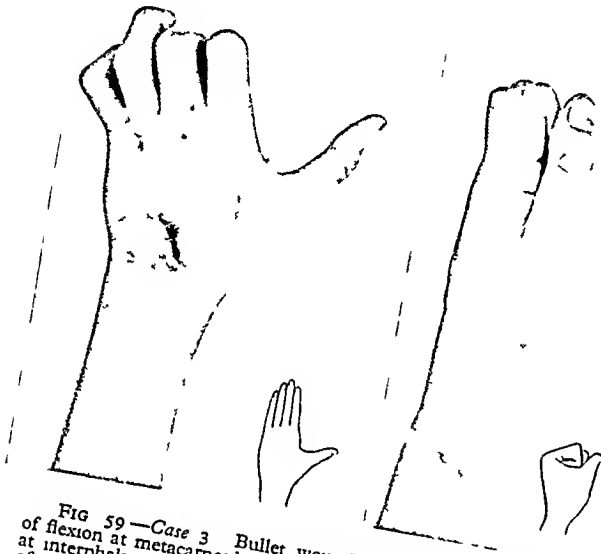


Fig 59—Case 3. Bullet wound of hand showing lack of flexion at metacarpophalangeal joints and lack of extension at interphalangeal joints. Deformity due to (1) involvement of extensor tendons in dorsal scarring, (2) scarring of long flexor tendons in palmar entrance wound, and (3) ulnar nerve lesion.

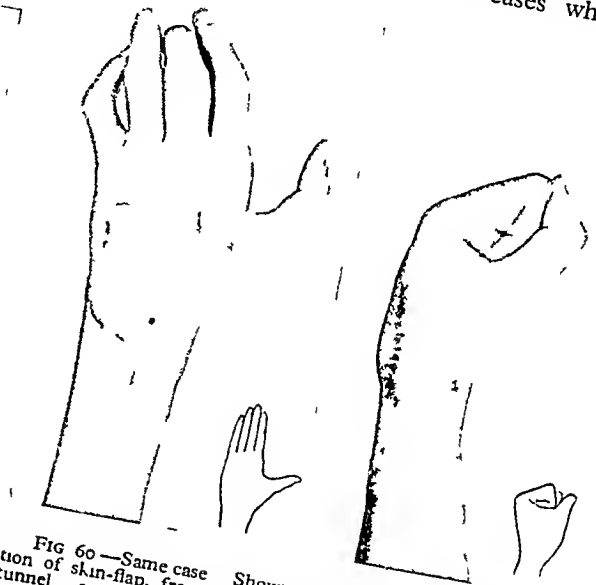


Fig 60—Same case. Showing improvement after application of skin flap, freeing of extensor tendons, and tendon tunnel operation. Note increase in range of movement at metacarpophalangeal joints.

intrinsic muscles and their nerve-supply are intact, and where periarticular contractures have not developed.

At operation, the dorsal scarring is excised and a skin defect established. The distal and proximal ends of the destroyed tendon or tendons are isolated. At this stage it is quite essential to secure a full range of movement at the appropriate metacarpophalangeal joints, to achieve this capsulotomy and division of the lateral ligaments may be required. The tendon graft, usually the tendon of the plantaris muscle from the leg, is then sutured to the distal stump of the extensor tendon.

A suitably placed abdominal skin-flap is now elevated and the hand brought into apposition with its raw surface. The tendon graft is then threaded across the flap, within the layer of fat on its deep surface, a trocar and cannula facilitates this manoeuvre. The proximal end of the tendon graft is then sutured to the appropriate extensor tendon, usually at the level of the posterior annular ligament of the wrist, and finally the abdominal flap is sutured in position in the skin defect on the dorsum of the

delayed the full deformity is likely to develop on account of the progressive contraction of the dorsal scarring, and sloughing of exposed extensor tendons or infection of the joints may take place, with the production of further deformities less readily treated. In most uncomplicated cases of this simple type where the injury is confined to loss of skin alone, early skin-grafting will prevent the occurrence of serious deformity, although the contraction of the primary grafts may necessitate further operations for release.

The late treatment of deformities of the hand caused by destruction of the dorsal skin consists in essence of radical excision of all scarring, the reduction of deformity, the release of joint contractures, and the application of skin-grafts to the freshly created raw areas. The operative details have been described elsewhere (Gillies and Cuthbert, 1943).

Cases 1 and 2 illustrate the deformity and the severe limitation of flexion which results after natural healing of a third-degree burn of the dorsum of the hand. The post-operative photographs show the improvement after a single operation for scar excision, mobilization of joints, and skin-grafting (Figs 55-58).

hand. The skin-flap is separated from its abdominal attachment in three weeks.

A similar operation may be performed where the extensor tendon is in continuity but is adherent to

extensor tendons or tendon grafts. In *Case 3* the fingers were virtually useless, at operation the extensor tendons were found to be in continuity but completely fixed in heavy scarring (*Fig 59*)

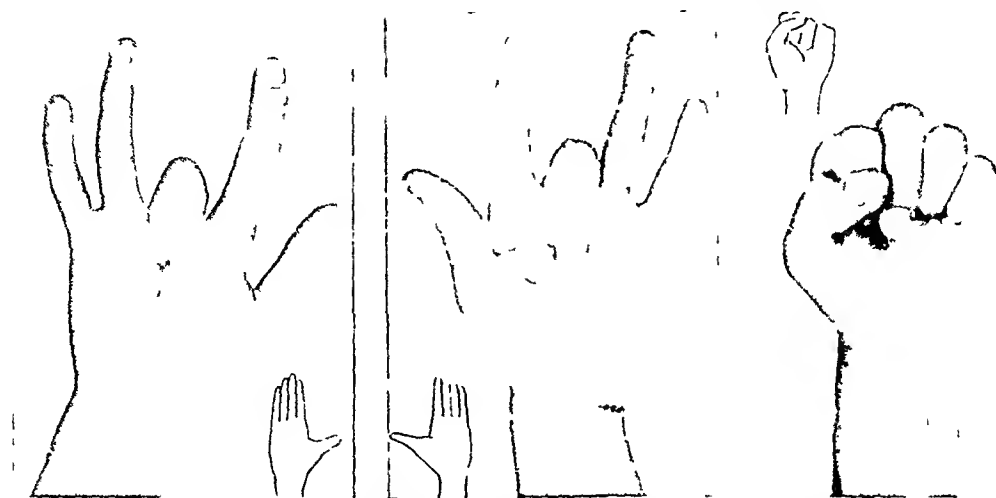


FIG 61—*Case 4*. Mortar wound of hand with united fracture of middle metacarpal and destruction of extensor tendon to middle finger. Complete inability to extend middle finger.

deep scarring. The tendon is divided above the level of the wrist, pulled distally, and threaded through the fat of an abdominal skin-flap and resutured at the point of division. The tendon thus passes through a layer of living fat and is completely prevented from the formation of adhesions. The value of the direct abdominal skin-flap in the late repair of complex hand injuries is

Application of the skin-flap and "tendon tunnel" operation produced a useful range of active movement at the metacarpophalangeal joints (*Fig 60*). In *Case 4* nearly 3 in. of the long extensor tendon of the middle finger were missing (*Fig 61*). The combined operation of skin-flap and tendon graft restored a good range of active movement to the finger (*Fig 62*).

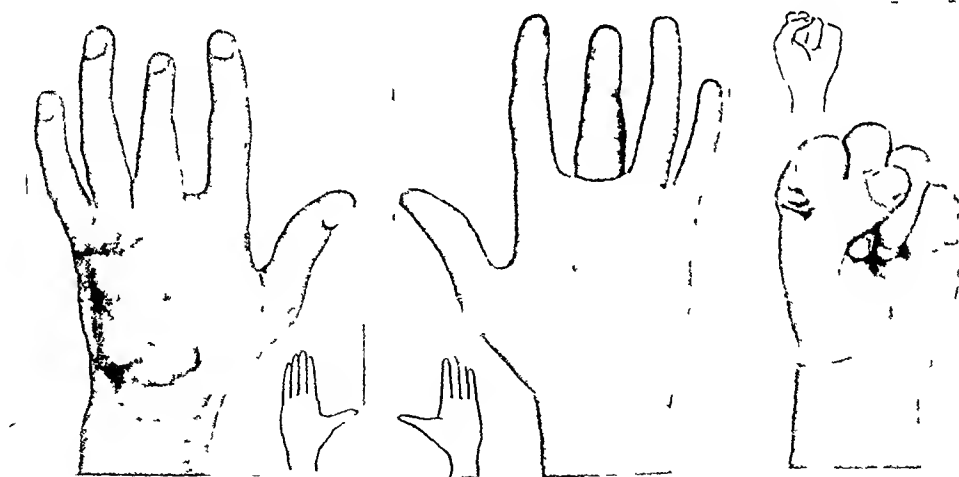


FIG 62—Same case. Result after dorsal scar excision, abdominal skin flap, and extensor tendon graft to middle finger inserted by "tunnel operation". A useful range of active extension has resulted.

considerable. With its use not only can skin losses be replaced, but operations upon bones, joints, and tendons can be performed under a covering of stable well-vascularized skin, without the misgivings associated with operations performed through an area of thin poorly vascularized scarring. The combined skin-flap and "tendon tunnel" operation was designed to secure freedom from adhesions for

#### *b* Destruction of the Extensor Expansion Dorsal to the Proximal Interphalangeal Joint.

—This lesion is commonly seen as an end-result of neglected burns of the dorsum of the hand, where sloughing of the tendon has followed prolonged exposure after destruction of the covering skin. In the less severe cases the skin and extensor expansion alone have been destroyed, and the end-result is a

finger clothed on the dorsum by thin unstable scarring, and flexed to a right angle at the proximal interphalangeal joint. Passive extension may be full or may be limited by periarticular contractures.

the joint is often required. *Case 5* is a typical example of the lesion and of the satisfactory result of the combined operation of direct skin-flap and extensor tendon graft. An almost full range of

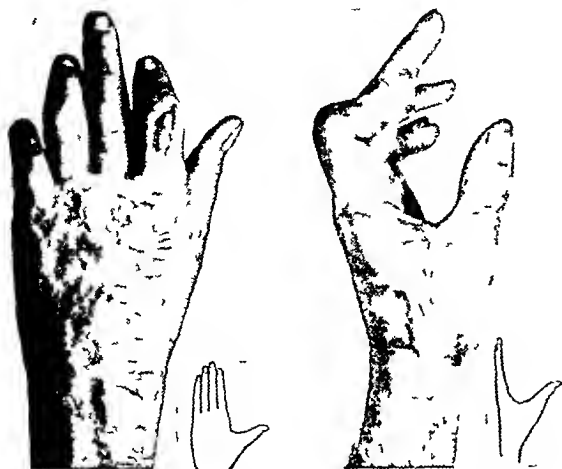


FIG 63—*Case 5* Dorsal burn of hand, chronic ulceration with sloughing of extensor tendon on index finger. Healed after application of direct skin-flap to dorsum of finger. No active extension at proximal interphalangeal joint.

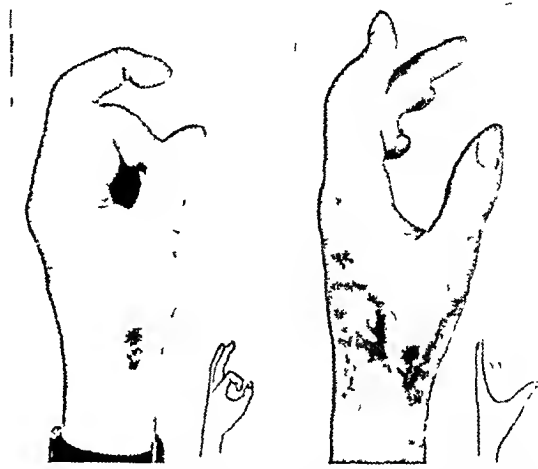


FIG 64—Same case, showing range of active movements at proximal interphalangeal joint after extensor tendon graft to index finger inserted by "tunnel operation".

In the more severe cases, the articular surfaces of the proximal interphalangeal joint have been destroyed as a result of infective arthritis, and there may be ankylosis with fixation in flexion, or there may be a few degrees of painful movement.

For the severe cases, reconstruction comprises excision of the dorsal scarring and provision of a stable skin covering, together with either arthrodesis

active extension of the proximal interphalangeal joint has been established (*Figs 63, 64*).

### 3 COMPLEX INJURIES OF THE DORSAL STRUCTURES OF THE HAND

These difficult cases comprise lesions of the dorsum of the hand or digits, in which there is destruction of skin and extensor tendons complicated

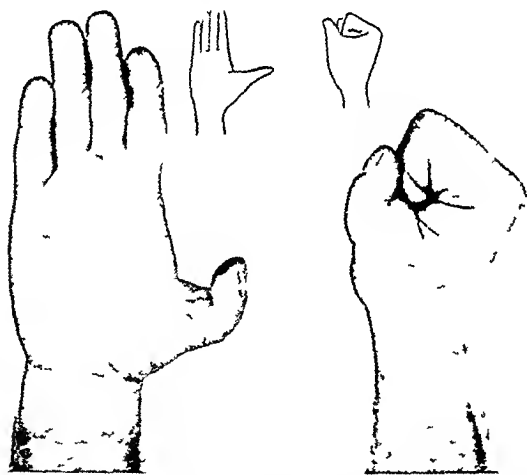


FIG 65—*Case 6* Healed wound of thumb with fracture of proximal phalanx with loss of bone, destruction of extensor tendon, and some skin loss. Active extension lacking.

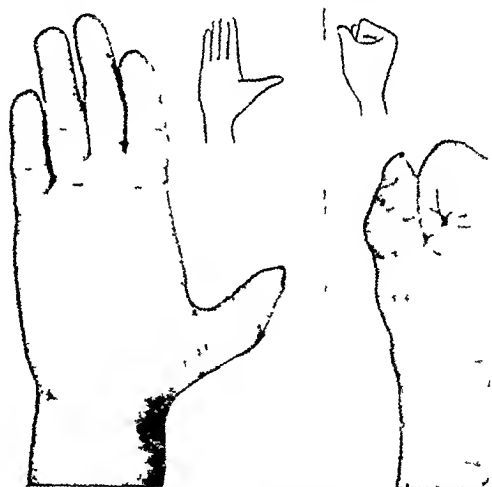


FIG 66—Same case. Result after bone-graft to proximal phalanx of thumb, direct abdominal skin-flap, and extensor tendon graft.

of the proximal interphalangeal joint in mid-flexion, or arthroplasty and extensor tendon grafting.

In the less severe cases, capsulotomy and the application of a skin-flap followed by tendon grafting to replace the destroyed extensor expansion will usually effect a cure. Before the tendon graft is inserted it is essential that a full range of passive movement of the joint should be established. Physiotherapy may accomplish this, but surgical freeing of

by fractures with loss of bone, or involving joints. The disabilities are similar to those already described, with the additional factors of shortening of the affected digits where there has been loss of bone, and of limitation of movement of joints which have been involved in severe open fractures.

Where the wound involves the dorsum of the hand, the metacarpo-phalangeal joints are usually immobilized either by joint damage or by fixation

of the long extensor tendons in scarring, or by a combination of both factors. The interphalangeal joints of cases in this group often show no active extension as there is commonly destruction of the interosseous muscles or interruption of their nerve-supply.

Where the wound involves the dorsal structures of the digits active extension is often lacking,



FIG 67—Case 7. Healed gunshot wound of hand with destruction of extensor tendons of thumb and loss of most of thumb metacarpal. Severe disability with loss of opposition and flexion of thumb.

immobilized interphalangeal joints commonly follow severe fractures, while phalangeal bone loss produces shortening and sometimes a flail digit with very little gripping power.

The complex cases may be conveniently divided into two groups, those with bone loss or non-union of fractures not involving joints, and those with severe joint damage.

Where joints are not involved, the plan of repair is as previously described, with the addition of an attempt to correct shortening of the digit, and the insertion of a bone-graft to bridge the bony gap. It is usually advisable to delay the insertion of the extensor tendon graft until the bone-graft has consolidated.

Case 6 illustrates the combined operation of skin-flap, bone-graft, and extensor tendon graft as applied to an old injury of the thumb showing loss of extensor tendon, some skin, and most of the shaft of the proximal phalanx (Figs 65, 66).

Where a joint is so severely damaged as to be rendered immobile, the possibilities of arthroplasty should be considered. It is not proposed to discuss in detail this rather discouraging subject, but to report on the use of free transplants of an entire joint as a method of arthroplasty. Gillies (1940) envisaged the possibility of an autograft of an

amputated digit based on the assumption that if the skin, subcutaneous tissue, and nail were removed, the amputated digit would be accepted as a free graft if buried under the skin of the abdomen. A successfully completed case of this procedure has recently been described by Gordon (1944).

Preliminary experiments of a simplified version embodying the same principle showed that a free transplant of an entire joint from the foot could be used to replace a destroyed joint in the hand. Case 7 (Figs 67–70) is an example of the application of the method. A gunshot wound had resulted in severe mutilation of the thumb. A large portion of the skin, most of the intrinsic muscles of the thumb, the extensor tendons, and the whole of the metacarpal except for its base had been lost. The long flexor tendon was intact. At operation, the skin loss was first made good by the use of a direct abdominal skin-flap. When this had healed satisfactorily, the fourth metatarsophalangeal joint was removed from the foot complete with its capsule, the recipient bone ends in the thumb were prepared and the free joint transplant wired in position with stainless steel wire. The joint was inserted in the reversed position, with its flexor surface facing dorsally so that the tightness of the dorsal capsule should not limit flexion. At a later stage extensor tendon grafting was performed. The end-result was a useful thumb with a good range of active flexion and extension at the new joint.

There is insufficient evidence as yet to assess the future value of this method of arthroplasty, but it is felt that the present results are sufficiently encouraging to warrant further trials.

All the extensor tendon grafts described were introduced by the "tunnel operation", and in all

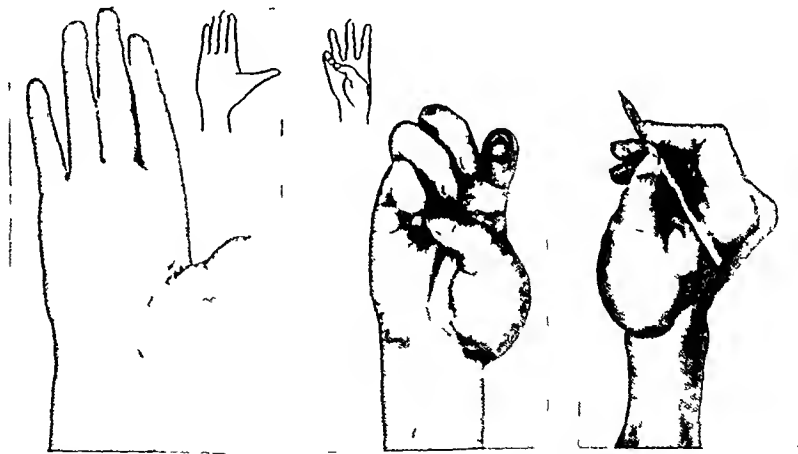


FIG 68—Same case. Result after scar excision, replacement of lost bone and destroyed metacarpophalangeal joint by free transplant of metatarsophalangeal joint, direct abdominal skin-flap, and extensor tendon graft. Note useful range of active movement.

cases the tendon of the plantaris muscle from the leg was used. Tendon suturing was performed with a continuous suture of fine stainless steel wire carried on an eyeless needle. I am indebted to Lt-Col K W Starr, A A M C, for bringing to my notice the virtues of the plantaris tendon (Glisson, 1934).

# ADDISONIAN ANÆMIA AFTER ENTERO-ANASTOMOSIS

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It is a pleasure to express my indebtedness to Sir Harold Gillies for his persistent encouragement cases, and to Mr E Butler for the clinical photography



FIG 69—Same case Pre-operative condition, showing loss of most of thumb metacarpal



FIG 70—Same case Post-operative condition showing free transplant of metatarsophalangeal joint in position Note range of active flexion and extension

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in the application of the principles of plastic surgery to the surgery of trauma My thanks also are due to Miss J L Morris, C S P, for ably undertaking the physical treatment and the rehabilitation of the

## ADDISONIAN ANÆMIA FOLLOWING ENTERO-ANASTOMOSIS

By J E RICHARDSON, SURGEON LIEUT -COMMANDER, R N V R

It is now well established that deficiency of the hæmopoietic principle of Castle is the main factor in the production of Addisonian pernicious anæmia. A secondary pernicious anæmia may occur in association with intestinal disease and fistulæ, where the apparent cause is the failure of absorption or the rapid elimination of the hæmopoietic principles.

The site and mode of action of the hæmopoietic principle are not yet known. In pernicious anæmia the body may suffer many pathological changes, in the bone-marrow there is failure of normal erythropoiesis, in the spinal cord there may be degenerative changes, whilst there is hæmolysis, with occasionally hæmolytic crises, due to the action of the reticulo-endothelial system. That one factor can act at three different sites in the body seems doubtful.

There is now evidence to show that it may act upon the intestinal mucosa, keeping it in a normal physiological condition, thus allowing it to absorb the normal physiological substances while preventing the access of toxins into the blood-stream, where they can bring about the multiple changes.

Briefly summarized, the evidence depends upon the production of a 'stricture anæmia', in dogs, following the creation of intestinal strictures (Seyderhelm et al, 1927). In those cases which failed to develop the anæmia the intestinal contents above the stricture remained normal.

Horster (1935), by creating blind pouches and strictures of dog's intestine, caused an anæmia to develop, this could be prevented by the administration of trichlorresol, an intestinal antiseptic, or campolon. Rhoads (1938), by giving indol to dogs fed on a deficient diet, produced a severe hæmolytic anæmia, this was prevented by giving liver extract.

In cases of sprue the absorption of glucose and fat may be increased by giving liver extract. Faber (1897), in the first recorded case of pernicious anæmia in association with intestinal stricture, suggested a "toxin" as the cause, comparing it with *Bothriocephalus* anæmia.

It seems probable that the hæmopoietic principle is essential in keeping the intestinal mucosa normal, should there be a deficiency of this factor the intestine allows the absorption of toxins which brings about the characteristic changes of pernicious anæmia.

In the event of intestinal stagnation there is excessive formation of toxins, which may damage the mucous membrane, even in the presence of a normal quantity of the hæmopoietic principle, and thus gain entrance to the blood-stream.

In intestinal strictures the mechanism is entirely due to the stagnation. In ileocolic fistula there is a loss of the normal absorption of the hæmopoietic principle and a stagnant loop below the fistula. The bigger the fistula the more rapid are the intestinal contents passed to the colon and the more stagnant will be the distal loop of small intestine.

The case here recorded had a large high fistula with a long stagnant loop of small intestine—an ideal combination for the development of pernicious anaemia

### CASE REPORT

**HISTORY**—H M, male, air mechanic, aged 20. In July, 1938, he was admitted to hospital with an attack of acute appendicitis. At operation he was found to have an appendix abscess, this was drained and no attempt was then made to remove the appendix. Five days after operation he had his bowels opened twice, and on the seventh day once. The drain was removed on the fifth day.

On the seventh day he commenced to vomit large quantities of bile-stained material and his abdomen became rather distended and tympanitic. The same evening laparotomy was undertaken through a left supra-umbilical paramedian incision. Distended plum-coloured small intestine bulged out of the wound. The transverse colon, which was collapsed, was brought down to the wound and a side-to-side anastomosis was performed between a loop of jejunum and the colon. The abdomen was closed with through-and-through sutures.

Four days after this second operation the patient commenced to have his bowels open. A week later he developed a faecal fistula in his paramedian wound, this discharged freely, but had practically healed up at the end of two months, when he was discharged from hospital.

He continued well, with occasional attacks of pain in the right side of the abdomen and a certain amount of diarrhoea.

In February, 1940, he was readmitted to hospital with a further attack of pain in the right side of the abdomen. On examination he was found to be tender in the right iliac fossa. His appendix was removed.

He joined the Royal Navy in November, 1943, and was admitted to hospital on Dec 16, when he was complaining of vomiting, diarrhoea, and shortness of breath.

The vomiting usually came on after meals, would last for a few days, and then clear up for periods of a fortnight. He used to bring up his food, never any blood. The vomiting had been present for the past twelve months. He had occasional slight epigastric pain associated with the vomiting and lasting for a few minutes.

He had had diarrhoea intermittently since his operation in 1938, this had been worse during the last twelve months. He had never noticed any black motions, the motions had been pale and offensive.

Since his operation in February, 1940, he had been short of breath. The dyspnoea had been increasing recently and he had been quite unable to run. Since joining the Navy he had not been able to carry out any of the physical training or exercises necessary for the training of air mechanics.

He had never noticed any swelling of his feet. His appetite had been poor, as he found that the food made him vomit. He had been steadily losing weight over the previous year. There was no disturbance of micturition.

There was no family history of any hæmatological disease.

He was employed in an aircraft factory prior to entry into the Service, but he was not exposed to any toxic chemical agents.

In October, 1943, prior to entry into the Service, he was given a barium meal. The œsophagus and stomach were reported as normal, the duodenum showed the typical deformity of an ulcer of the duodenal cap. There was no stenosis. The patient was screened after 1, 2, 3, and 6 hours and no abnormality was discovered. The

6-hour film showed that the barium had reached the colon (it is not stated in the original report whether it was the ascending or transverse colon).

**ON EXAMINATION** (Dec 16)—He was a very pale, wasted youth. Weight, 7 st 10 lb, height, 5 ft 3 in. There was marked pallor of the mucous membrane and a sub-icteric tint of the conjunctivæ. There was no cyanosis or œdema. There were no petechial hæmorrhages of the skin or mucous membrane. There was superficial glossitis. The tonsils were not enlarged, the teeth were good, the gums were a little soft. There were a few slightly enlarged lymph-glands in each side of the neck. There was no enlargement of the epitrochlear, axillary, or inguinal glands. The thyroid was not enlarged. There was no clubbing or koilonychia of the fingers, the nails were of a normal consistency.

There was no abnormality of the chest, cardiovascular system, or nervous system.

**Abdomen**—This showed the scars of three previous operations. The spleen was not palpable. There was no visible peristalsis. There was no tenderness or rigidity, no abnormal masses to be palpated, no ascites.

The urine was normal.

**A fractional test-meal** showed free and total acid to be present, with increased acidity after the first hour. No blood was present in the stomach contents.

**Blood** (Fig 71). Bleeding and clotting times were normal. Platelet count was normal. The differential white-cell count was within normal limits. On Dec 28 these were 1,680,000 red blood-cells per c mm with 40 per cent hæmoglobin, giving a colour index of 1.2. The subsequent reading also gave a high colour index, anæmia. On this date the reticulocytes were too few to estimate. On Dec 29 he was given 2 c c of liver extract. On Jan 3, 1944, there were 1 per cent reticulocytes, following five injections of 2 c c liver extract the reticulocytes rose to 8 per cent on Jan 10. The blood-film showed "gross microcytosis with poikilocytosis and fairly numerous well-stained megalocytes, the whole picture being typical of an anæmia of the pernicious type. There were also some smaller poorly stained cells, suggesting a possible coexisting iron deficiency."

**Stools**. The occult blood test was negative on Dec 18 and Dec 20. On Dec 28 it was found to be positive and remained positive until after operation. The stools were large, pale, and offensive. Microscopically they did not contain any undigested food. After commencing treatment with iron part of the stools became dark.

The blood-calcium was 8.4 mg per 100 c c (Jan 1, 1944).

**TREATMENT**—The patient was placed on a modified gastric diet with extra vitamins. Large doses of iron by mouth, liver extract intramuscularly and calcium by mouth. He was given fresh whole blood transfusions—3 pints on Dec 29, 1943, 5 pints on Jan 1, 1944, and 3 pints on Jan 26. On Jan 30 he was commenced on a course of sulphaguanidine, 2 g as an initial dose, followed by 1 g 4-hourly for three days.

**Operation** (Feb 2, 1944)—(Anæsthetic open ether given by Surg-Comdr E E D Gray, R N V R.) The old supra-umbilical paramedian scar was excised and the anterior layer of the rectus sheath was opened. The peritoneum was opened above and below the site of the old fistula and the intestine was then dissected away from the posterior layer of the rectus sheath where it was adherent. The site of the original anastomosis was found lying just under the wound, the stoma being situated well up in the jejunum. The small intestine was divided from the large. The stoma measured about 3 in in length. The transverse colon was then sutured, the omentum being brought down to cover the suture line. The small intestine was sutured transversely and returned to the peritoneal cavity. A drain was inserted to the transverse colon and a second into the pelvis. The wound was closed.



**Post-operative Treatment**—He was given 2 pints of fresh whole blood, followed by glucose-saline by slow drip intravenously for three days. Sulphapyridine, 2 g, as an initial dose, followed by 1 g 4-hourly for three days. He was given three further injections of liver extract intramuscularly and commenced on iron by mouth on the fourth day after operation. On the third day after operation he was started on a milk diet—this was gradually increased.

**PROGRESS**—The second day after operation his abdomen became a little distended. On the third day

there is an absolute achlorhydria, in this case, as the cause of the anæmia was the intestinal fistula, achlorhydria was not to be expected, in fact, due to the peptic ulcer, analysis of the gastric contents showed hyperacidity.

The anæmia was complicated by the presence of the duodenal ulcer, which bled after the admission of the patient to hospital, this both complicated the picture of the anæmia and necessitated treatment by blood transfusions before it was possible to ascertain the maximum response to treatment with liver extract and iron.

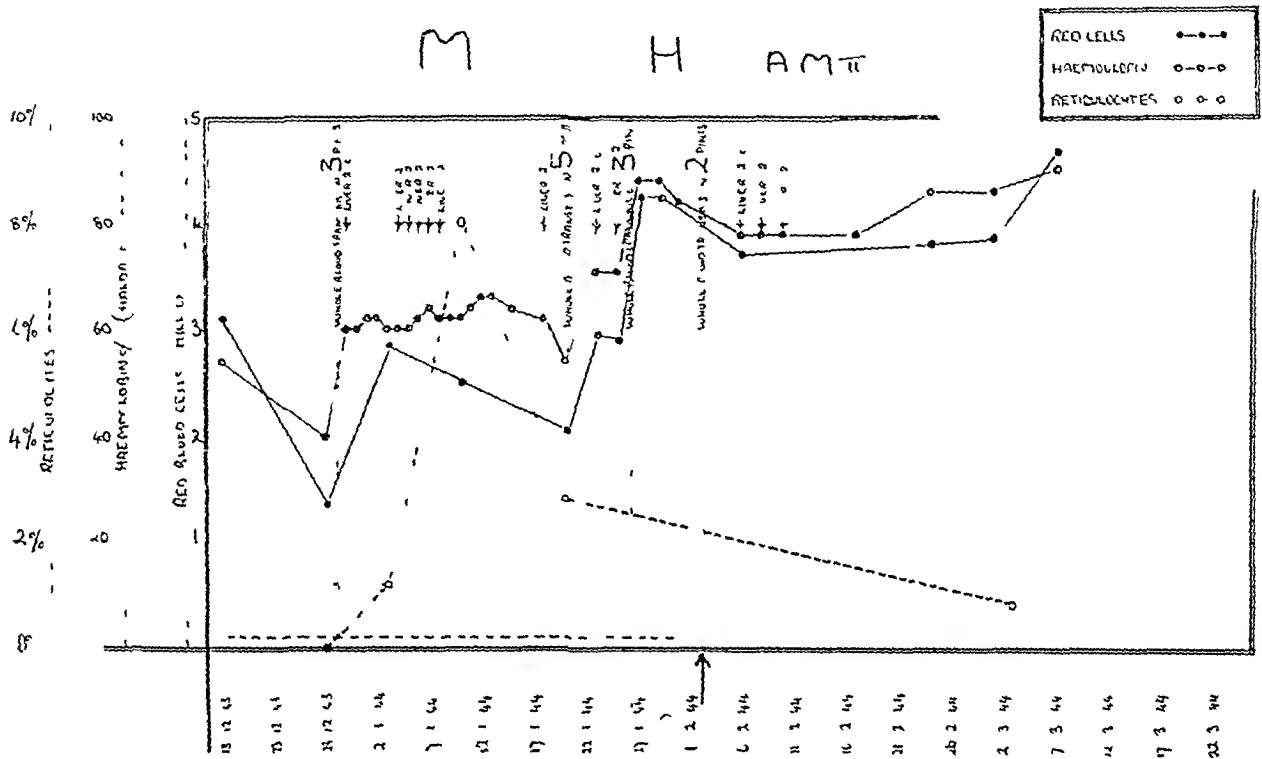


FIG 71—Blood examination chart

his bowels were opened and continued to be opened regularly each day, the motions being of a normal colour and formed. He steadily put on weight, on discharge from hospital, March 13, weighing 10 st 7 lb. His hæmoglobin and red cells have steadily increased since operation, on March 8 having 90 per cent hæmoglobin and 4,680,000 red cells. The conjunctivæ lost the subicteric tint, the gums became normal, the tongue improved. The stools occult blood-test has been negative since the operation.

He was seen on April 28 after a period of sick leave. During this time he did not have any treatment. His weight was 11 st 11 lb. His tongue and conjunctivæ were normal. The blood showed 98 per cent hæmoglobin and 4,900,000 red blood-cells. The blood-picture was normal. The stools were negative for occult blood, the fractional test-meal showed a normal curve. The urine was normal.

The patient was last seen on Dec 18. He had then completed an assault course and had finished his full training as an air mechanic. His weight was 12 st, his blood showed RBC's 5,160,000, WBC's 11,000, hæmoglobin 104 per cent, CI 1.0.

#### Comment—

**Type of Anæmia**—The clinical appearance, the high colour index, the reticulocyte response, and the typical blood-picture definitely indicate that this was a pernicious type anæmia. In the true Addisonian pernicious anæmia, in which there is atrophy of the mucosa of the stomach,

The relief of the Addisonian anæmia which followed the closure of the intestinal fistula establishes the relationship between the fistula and the anæmia.

## DISCUSSION

**Intestinal Disease associated with a Pernicious Type of Anæmia**—In 1939 W Halsey Barker and Edgar Hummel were able to collect from the literature 49 cases of macrocytic anæmia occurring in association with intestinal strictures and anastomoses, to which they added 2 cases of their own. Of these 51 cases, 18 were due to fistulæ, in many cases following an operation for intestinal obstruction occurring after appendectomy.

Twenty-three of these cases had neither medical nor surgical treatment (many of the cases being recorded before Minot and Murphy's discovery of the hæmopoietic factor). Of these, 22 patients died, the remaining patient was untraced. Nine patients had operative treatment alone, with 4 survivals. Nine patients had intensive treatment by liver extract, and 6 of them showed very considerable and satisfactory improvement. In the remaining cases medical treatment was at first attempted by means of liver extract and a diet suitable for sprue.

Owing, however, to persistence of the anæmia or gastro-intestinal symptoms, surgical treatment had subsequently to be undertaken, 5 of these patients died after the operation

Many of these operations were undertaken for very complex intestinal derangements, such as multiple tuberculous strictures and gastro-jejuno-colic fistulæ, and of necessity carried a high mortality. In some cases the primary lesion, cancer or tuberculosis, was responsible for death

In the light of the case here recorded and the cases referred to above, the best procedure is to treat all the cases by medical means. Those cases which fail to respond to medical treatment, may, in addition, require surgical treatment to restore the normal continuity of the bowel. The possible benefit from this procedure would be balanced against the practical difficulties and magnitude of the operation in each individual case

In considering the treatment of intestinal stricture with obstruction the possibility of a short-circuit anastomosis precipitating a pernicious anæmia must be remembered. In view of the dual nature of the aetiology, it would be physiologically correct to resect the diseased bowel in order to avoid creating a stagnant loop. The risk of precipitating the anæmia might be justified by the condition of the patient, the pathological nature, or the anatomical extent of the disease

**Jejunocolostomy**—Jejunocolostomy is sometimes advocated for the relief of early post-operative intestinal obstruction. It is assumed that the stoma will close when the inflammatory tissues around the lower ileum are absorbed. This is, however, untrue

Conservative treatment of these cases of obstructions seems to give a greater chance of success than operative treatment. Any operation at such a time

is performed on an ill patient through an infected peritoneum. The immediate chance of survival following jejunocolostomy must be small, and later it carries the risk of serious sequelæ

**The Duodenal Ulcer**—The aetiology of peptic ulcers is still unknown. In this case it is tempting to think that there was some relation between the ulcer and the general malnutrition of the patient. It does possibly give some support to the theory that deficiency plays a part in the production of these ulcers

## SUMMARY

A case with a jejunocolic fistula giving rise to fatty diarrhœa and a pernicious type of anæmia is recorded

This fatty diarrhœa and the anæmia were relieved by the closure of the intestinal fistula

The patient also had a duodenal ulcer. The possibility of this being related to his general malnutrition is suggested

I wish to express my thanks to the Medical Director-General of the Navy for permission to publish this article, also to Professor L. J. Witts for his helpful criticism, to Lieut.-Col. R. R. Bomford for his report on the blood-film, and to Surgeon Rear-Admiral Gordon-Taylor for his advice about this case

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## EXPERIENCES IN THE PROPHYLAXIS AND TREATMENT OF CLOSTRIDIAL INFECTIONS IN CASUALTIES FROM THE INVASION OF EUROPE

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 AND SURGEON LIEUT.-COMMANDER H. W. CLEGG, R.N.V.R.

SOME 1360 casualties were received in a naval hospital in a relatively short time immediately following the invasion of Normandy in June, 1944. All these patients were considered so ill and so urgently in need of treatment on landing as to be unfit to travel beyond the port of reception in England. There were 113 cases clinically suspicious of gas gangrene, from 53 of which clostridia were isolated.

The present report comprises 16 of these cases of anaerobic infection and covers all the examples of undoubted gas gangrene, *sensu restrictu*, with, in addition, one doubtful case which we shall regard as severe anaerobic cellulitis, included for reasons which will be apparent later. The term 'gas gangrene' is used in accordance with the definition of MacLennan (1943), and the cases are presented because they have produced results felt to be of great interest at the present time. As a group, they all received treatment such as transfusion with

blood and/or serum, anti-gas-gangrene serum, sulphathiazole, and surgery as seemed indicated. These factors apart, some received penicillin prophylactically, some both prophylactically and therapeutically, while some received no penicillin at all. 'Resuscitation' referred to herein includes full modern treatment of shock together with transfusion

## CASE REPORTS

Table I gives the essential surgical details of the cases, with the amount of any drug used and the infecting clostridia isolated from the wound. Cases 1, 15, and 16 are given below in greater detail because they are typical case histories and are to be referred to again later.

**Case 1**—A German P.O.W., aged 42. Wounded June 6, 1944. Had transfusions and sulpha-drug in the field, but details unknown. Admitted June 9. G.S.W. left elbow and compound fracture lower third of humerus

Case 16 — Sapper, aged 19 Wounded June 6, 1944  
Multiple splinter wounds of the left thigh and leg  
Knee-joint opened Open fracture of left tibia and fibula  
Lacerations of scrotum and right arm and forearm This  
man had penicillin during the three days between being

### HISTOLOGY

Owing to the rush of work in the theatres and elsewhere it happened that only a limited number of specimens were sent to the laboratory for histological examination. The list does not tally altogether with the cases set out in the *Table*, since some

of the tissues came from other hospitals and no case histories were made available. Again, in some instances, they were received in formol-saline so that no corresponding bacteriological investigation was possible, and in other instances they turned out to be cellulitis, not real gas-gangrene myositis, and are therefore not included in this report.

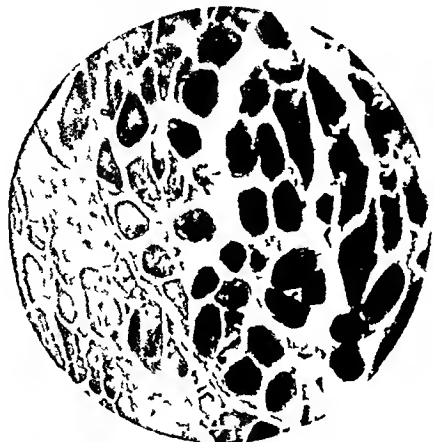


FIG 72—Case 1 Gas-gangrene myositis. Shrinkage of fibres (right) progressing through fragmentation to necrosis (left). Wide connective-tissue spaces contain clostridia. Gram ( $\times 75$ ).

other hand, they contain large numbers of Gram-positive rods, and in areas where the disease is more advanced these bacilli are seen also within the strands of disorganized muscle.

For purposes of contrast to the above, Figs 74 and 75 are taken from one of the cases of anaerobic cellulitis.



FIG 73—Case 1 Clostridia in tissue spaces and in devitalized muscle. Gram ( $\times 300$ ).

There are sections of muscle from twelve different patients, but only four of these appear in the table—Cases 1, 2, 3, and 14.

The salient points of the true myositis could be seen over various fields in the slides, and some of

The spaces between muscle bundles are markedly widened, clear, oedematous in places, or the site of extravasated RBC's, but, for the most part, they show heavy infiltration with polymorphs, even to the extent of small abscess formation. The effect on the muscle fibres varies through shrinkage,



FIG 74—Anaerobic cellulitis. Gradual destruction of muscle. Tissue planes crowded with inflammatory cells. Bits of fine thready material from clothing embedded in abscess area (top left). H & E ( $\times 75$ ).

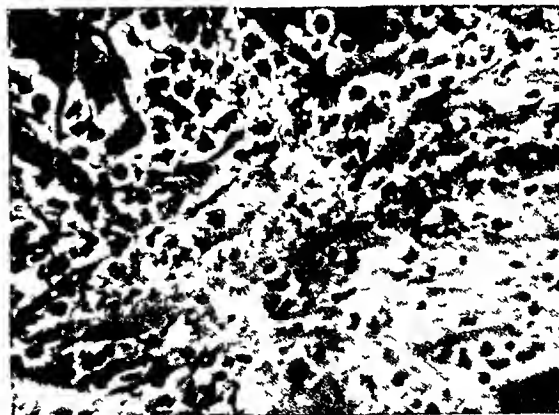


FIG 75—Inflammatory cell infiltration of muscle planes and fibres. Gram ( $\times 300$ ).

them are depicted in Figs 72 and 73 taken from preparations belonging to Case 1. In general the tissues exemplified all the gradations in intensity of the gangrenous process, from initial ischæmia, a shrinkage of muscle-bundles in their sheaths, on to loss of striæ, nuclei, and sarcolemmæ, and thence to fragmentation and gradual autolytic disintegration into devitalized structureless debris.

Withal, there is a striking absence of any septic infiltration along the perimysial connective-tissue planes, which are quite empty of cells. On the

loss of striations, and fragmentation, to areas of complete destruction. Masses of Gram-positive bacilli were found in the necrotic parts.

### TREATMENT

**Surgery**—The object has always been to extirpate as fully as circumstances would allow any gangrenous muscle—by local excision or, if no alternative remains, by amputation. Sites where muscle had been excised and incisions made into infected tissue were irrigated freely with warm hydrogen peroxide solution to remove debris, lightly dried,

and usually then insufflated with a 'frost' of sulphathiazole and 1 per cent neutral proflavine. This irrigation and frosting, used once or twice subsequently, would frequently produce a wound which looked surgically so clean that early secondary suture would be possible.

**Penicillin**—Cases 4, 5, 7, 8, 9, 12, 13, and 16 received penicillin prophylactically as part of the M R C 'Yellow Label' Scheme for the prevention of gas gangrene. This is designated in *Table I* as 'before arrival', and, where the field medical card gave the information, the amount received is shown. Where it is known that penicillin was received but not the quantity, it is shown as amount 'not known'. Where treatment with penicillin was given it was usually as a continuation of such prophylaxis, but some cases were considered to be suitable for this therapy to be commenced in hospital. The route was by intramuscular injections, at first 45,000 units every 5 or 6 hours, but later, because it was discovered that this time interval could not always guarantee an adequate blood-level, we resorted to 15,000 units every 3 hours. Only 2 patients received penicillin locally (Cases 9 and 14), the first as penicillin cream and the latter in solution. On the whole, the intramuscular injections were well tolerated, although some patients complained after 8 or 9 injections of pain at the site of injection, and considerable persuasion became necessary before the course could be completed.

**Sulphathiazole**—Sulphathiazole has been the drug of choice in this hospital, and when a patient was put on to it a course was commenced with 2 g followed by 1 g every 4 hours, thus assuring at least 6 g daily. This course was given if the patient was not on penicillin. When the patient was on penicillin the sulphathiazole was also given in some cases, because of the confidence the surgeon in charge of the case had in the drug. He did not feel justified in bartering it for penicillin until more is known about the action of the latter in clinical gas gangrene. Some of the patients had the drug locally only. The local application was by insufflation in combination with 1 per cent neutral proflavine.

**Anti-gas-gangrene Serum**—The serum used was Burroughs Wellcome & Co's Refined Gas Gangrene Polyvalent Antitoxin-Globulin, each 5 c.c. of which contains—

*Cl. perfringens* 9000 IU    *Cl. septicum* 4500 IU  
*Cl. oedematis* 9000 IU

The normal procedure was to give 15–30 c.c. intravenously, diluted with equal parts of saline (via the tubing of the intravenous serum or blood-drip, if available), and to supplement this with 15 c.c. intramuscularly. The dosage was repeated every six hours until it was considered that the toxæmia had been eliminated and that it was reasonably certain that the wounds were well on the way to recovery, and no longer likely to become a renewed source of toxin. This necessitated carrying on with anti-gas-gangrene serum injections for a day or two longer than had been customary, but we have seen no ill effects as a result of such big dosage. The largest dose received by any patient was 400 c.c. (1,800,000 units).

## RESULTS

There was 1 death in the 16 cases (Case 13), from bronchopneumonia. His hæmoglobin had fallen to 26 per cent (Haldane) 3 days after admission, when the clostridial infection had been overcome, and there is no doubt that, as also pointed out by Jeffrey and Scott Thomson (1944), careful watch must be kept for such a fall. After our experience in this case we instituted daily hæmoglobin estimations in all our casualties, and efforts were made to keep the hæmoglobin level at 80 per cent (Haldane) by transfusion.

There were 6 amputations, 3 arms and 3 legs (Cases 1, 5, 7, 9, 12, 13). Cases 15 and 16 are in this respect of outstanding interest. Case 15 had a gangrenous biceps femoris, but it is doubtful if Case 16 was a true gas gangrene in the sense of clostridial myositis. Yet both cases looked so ill that they were considered by the surgeon, who has had a large experience and on whose judgement we rely, to be quite unfit for operative treatment and it was confessed later that they were looked upon as hopeless. Their lower limbs were grossly distended and the œdema had spread over the inguinal region into the anterior abdominal wall, where crepitations could easily be elicited. They were returned to the ward, where intensive therapy with anti-gas-gangrene serum was commenced, Case 15 receiving 1,147,000 IU and Case 16 1,800,000 IU. Case 15 received only 2 g of sulphathiazole and Case 16 had this drug only locally (with proflavine). While Case 16 had a full course of penicillin (and had had an unknown amount prior to admission), Case 15 had only 90,000 units. The remarkable thing is that, within 24 hours of commencing this intensive anti-gas-gangrene serum therapy, there was such a remarkable clinical improvement that it was considered safe to perform excision and incision, which was all the surgery required. *Neither case had the amputation for which he was originally destined.*

The remaining cases recovered after excision or incision combined with anti-gas-gangrene serum and either penicillin or sulphathiazole, without loss of limb.

## DISCUSSION

Difficulties attend the assessment of the value of a drug, even a stable one, in the clinical field and these difficulties are greater with penicillin, which is exacting to handle and apply efficiently. Moreover, a surgeon does not easily forego the tried and trusted methods of which he has had experience, and while he may be prepared to use penicillin in addition to surgery, antitoxins, and chemotherapy, he is unwilling, in a disease of such gravity as gas gangrene, to use it to the exclusion of these other aids. It would, therefore, be unreasonable to draw definite conclusions from such a small series of cases as is presented here. There are, however, certain facts which have impressed themselves upon us as a result of our experience.

Eight cases (Cases 4, 5, 7, 8, 9, 12, 13, 16) had penicillin prophylactically, but gas gangrene developed in each of them (except perhaps Case 16). In our experience it could not be guaranteed to

prevent the development of anaerobic cellulitis. The number of cases developing gas gangrene is too small to judge of any prophylactic value and in no case was the dosage as large as it should have been, had the recommended dose of 45,000 units been repeated every five or six hours after an initial one of 90,000 units. Nevertheless, it would be unfair to ascribe any such property to penicillin so administered. Nor could we see any evidence of such property in either anti-gas-gangrene serum

certain that the source of toxin production is controlled. It has always been our custom to give a dose of anti-gas-gangrene serum intravenously during the operation if the nature of the wound is such that a flood of toxin is likely to be liberated as a result of movement and handling. Of any single aid to surgery (after resuscitation) we think that anti-gas-gangrene serum is the most useful when the infecting organism is represented in the antitoxin, and the dramatic improvement produced

Table I—SURGICAL DETAILS, DOSAGE

CASE No	LESION	FRACTURE	ARTERY DAMAGED	MUSCLE GROUP INVOLVED	OPERATION
1	Shell splinter wound, L arm	Humerus	Brachial	Triceps	Amputation and excision of triceps
2	Shell splinter wounds, both thighs and buttocks	Ischium	None	Semitendinosus, biceps femoris	Excision of muscle and removal of foreign body with wide excision
3	Shell splinter wounds, buttocks, thighs, and foot	Os calcis	None	Gluteal	Incision and removal of foreign body and clothing
4	Shell splinter, traumatic amputation lower third thigh	Femur (comminuted)	Femoral	Abductors	Excision, late fashioning of flaps
5	Shell splinter, thigh, division of sciatic nerve	Femur (comminuted)	None	Hamstrings, abductors, semitendinosus	Amputation
6	Shell splinter, buttock	None	None	Gluteal	Excision and incision
7	Shell splinter, leg	Tibia and fibula (comminuted)	Anterior and posterior tibials	Calf	Amputation
8	Shell splinter, both buttocks and leg	None	None	Biceps femoris, semitendinosus, semimembranosus	Excision
9	Shell splinter, right deltoid	Humerus (comminuted)	Brachial	Whole of forequarter	1 Amputation before arrival 2 Flaps opened, muscle excised
10	Shell splinter, right leg	Tibia and fibula (comminuted)	Anterior tibial thrombosed	Anterior tibial group	Incision and excision
11	Shell splinter, left leg	None	Posterior tibial	Muscles of calf	Excision
12	Shell splinter, left leg	None	Anterior and posterior tibials	Anterior and posterior tibials	Amputation
13	Shell splinter, arm and forearm	Humerus, radius, and ulna	Brachial	Biceps, triceps, and all forearm muscles	Amputation
14	Shell splinter, both thighs, legs, feet, right shoulder, and hands	Femur	None	Semitendinosus, semimembranosus	Excision
15	Gunshot wound, thigh	Femur (comminuted)	None	Biceps femoris	Incision and excision
16	Shell splinter, leg and knee-joint, scrotum	Tibia and fibula	None	Thigh and abductors	Incision

or sulphathiazole, and there is no doubt that at present surgery is our most powerful prophylactic ally.

The death of only 1 patient, Case 13 (and that from bronchopneumonia after the clostridial infection had been controlled), out of 16, is remarkable. Cutler and Sandusky (1944) report 7 cases with 1 death and MacLennan (1943) has knowledge of a hospital in the Middle East where 11 consecutive cases of gas gangrene had been treated, with only 1 death. Cutler and Sandusky consider that early diagnosis and prompt surgical extirpation of infected tissue are of the greatest importance in the prophylaxis and treatment, whilst MacLennan is impressed by the aid given to surgery using a combination of anti-gas-gangrene serum and sulphathiazole. Our belief is that the keystone of treatment is adequate surgery, with the object of totally removing all infected tissue, opening of muscle planes and areas of cellulitis, with the establishment of good drainage. This surgery should always be accompanied by big doses of anti-gas-gangrene serum given before the operation and continued afterwards, until it is

in Case 15 by it (the small dose of penicillin and sulphathiazole can really be ignored) bears testimony to its power. But we agree with MacLennan (1943) that it should be combined with sulphathiazole systemically. Applied locally in combination with 1 per cent proflavine by insufflation it has produced in our hands, after 2 or 3 applications, a wound which looked so surgically clean that early secondary suture was possible.

As regards penicillin in the therapy of gas gangrene we find ourselves unable to believe that its value is proven when given systemically only and we do not share the confidence apparent in many published reports. Combined with local penicillin the results may be better, although Cutler and Sandusky (1944) used systemic and local penicillin in the treatment of gas gangrene and were unconvinced of its effectiveness. As stressed by Bentley et al (1945), for any systemically applied antibacterial agent to be effective the blood-stream must carry the agent in sufficient concentration into contact with the organisms under attack. It is emphasized that this may be impossible in large



wounds complicated by fractures where loculation has occurred and where hæmatomata may be numerous. Any agent would have to find its way to the bacteria in such situations by infiltration or transudation, and in fact might never reach the infected area or only in small concentration. Also the natural state of the blood-supply to a tissue is important. In this respect Case 14 is of interest. Penicillin assay of exudate from the shoulder wound and right foot revealed that, although the penicillin was present in the

may be accompanied by gangrene of underlying muscle, it does not necessarily follow in every case. We note that Jeffrey and Scott Thomson (1944) have had the same experience.

Such involvement of superficial tissue and the muscle planes beneath the superficial fascia was often noted elsewhere, but even when associated with true gangrene of the underlying muscles, the skin frequently survived when the gangrenous muscle had been removed.

## OF DRUG, AND ORGANISM ISOLATED

PENICILLIN	ANTI-GAS-GANGRENE SERUM	SULPHA-DRUG	RESULT	ORGANISMS (Clostridia)
Nil	1,552,000	39 g	Recovery	<i>Cl welchii</i>
Nil	607,000	40 g	Recovery	<i>Cl tetanomorphum</i> <i>Cl welchii</i>
Nil	1,222,500	6 g local before arrival	Recovery	<i>Cl welchii</i>
180,000 before arrival	783,000	25 g Sulphathiazole and proflavine local	Recovery	<i>Cl welchii</i> <i>Cl cochlearium</i>
90,000 before arrival	215,000	5 g before arrival	Recovery	<i>Cl welchii</i>
1,485,000	120,000	40 g	Recovery	<i>Cl welchii</i> Unidentified
1,080,000	404,000	Nil Sulphathiazole and proflavine local	Recovery	<i>Cl tertium</i> <i>Cl welchii</i>
100,000 before arrival	409,000	14 g	Recovery	<i>Cl welchii</i> <i>Cl tertium</i>
720,000		Local before arrival	Recovery	<i>Cl tertium</i>
150,000 before arrival		Local		
785,000				
Amount before arrival not known	90,000 before arrival	Amount before arrival not known	Recovery	<i>Cl welchii</i>
90,000	1,800,000	20 g		
Cream locally (500 units g)				
630,000	45,000 before arrival	Amount before arrival not known	Recovery	<i>Cl welchii</i> Unidentified
450,000	1,350,000	31 g	Recovery	<i>Cl welchii</i>
	2,340,000	34 g		
		Sulphathiazole and proflavine local	Recovery	
Amount before arrival not known	1,260,000	40 g	Recovery	<i>Cl welchii</i> <i>Cl tertium</i>
135,000 before arrival	13,500 before arrival	11 g	Died	<i>Cl welchii</i>
90,000	910,000	Local		
1,980,000	Amount before arrival not known	Amount before arrival not known	Recovery	<i>Cl welchii</i> <i>Cl tertium</i>
3,000 local	1,012,500	15 g		
		Sulphathiazole and proflavine local	Recovery	
90,000	67,500 before arrival	2 g	Recovery	<i>Cl welchii</i> <i>Cl tertium</i>
Amount before arrival not known	1,079,500		Recovery	Unidentified
1,035,000	1,800,000	Sulphathiazole and proflavine local		

former, it was absent in the latter. The tissue involved in the foot was relatively fibrous and the blood-supply naturally not so profuse as to the muscles and soft tissues in the shoulder. 3000 units of penicillin in solution were applied to the foot, and a swab taken three days later showed that the *Cl welchii* which had been present before had disappeared (penicillinase was added to the culture to neutralize any penicillin carried over).

Cases 15 and 16 illustrate how ill a patient can look when œdema, crepitus, and discoloration are apparent in the anterior abdominal wall, having spread over the inguinal ligament from the thigh. These two patients looked so toxæmic that they were considered at the time inoperable and hopeless, but 24 hours later, after intensive therapy with anti-gas-gangrene serum (Case 15) and anti-gas-gangrene serum with penicillin (Case 16), they were dramatically improved and limited conservative surgery was undertaken, which proved ultimately to be all the interference required. Such spread into the abdominal wall is, therefore, not to be regarded as of hopeless significance, because, although such a state

## SUMMARY

1. 16 cases (15 of them gas gangrene) are reported with only 1 death.

2. It is considered that adequate surgery is still the keystone of prophylaxis and treatment of gas gangrene.

3. The most useful aids to surgery at present are anti-gas-gangrene serum in combination with penicillin. The place of penicillin in the prophylaxis and treatment of gas gangrene is not proven and must remain uncertain until further investigations have been carried out.

4. Spread of œdema, crepitus, and discoloration into the anterior abdominal wall from the thigh does not necessarily mean a hopeless prognosis.

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## LAWSON TAIT

BY SEYMOUR BARLING

LAWSON TAIT was one of the most dynamic personalities in Mid-Victorian surgery and owed much of his pre-eminence to the fact that he had qualities which were so perfectly matched to the times in which he lived. He was a pioneer with great courage and resource and a high degree of technical skill and a temperament well suited to indulge in the robust controversy which was such a noticeable feature of medical life in this period.

Born on May 1, 1845, in Edinburgh, his school life and student days were spent in that city until he qualified in 1866. After a period of travel he was appointed as House Surgeon to the Wakefield Hospital in 1867. During the period he held this post until he came to Birmingham in 1870 he appears to have operated on a wide range of cases, including his first ovariectomy, although he left Edinburgh under the influence of Syme with the firm resolve "not to deliberately open the abdomen."

Coming to Birmingham at the age of 25 he spent the whole of his active professional life there until his death in 1899, his most fertile work being produced between 1870 and 1890 and reaching its zenith at about the middle of this period. He came to maturity at the end of one surgical epoch and his energy and skill made him one of the great figures in world surgery in the next forward surge.

Syme, the last of the great pre-Listerian surgeons, died in 1870, anaesthesia, yet in its infancy, was opening up fresh fields to surgical enterprise, whilst the genius of Lister was beginning to unravel the tangled skein of sepsis, his first lecture, "On a New Method of Treating Compound Fractures, Abscesses, etc.", being delivered in 1867. The one dark cloud on the surgical horizon was the terrible mortality from sepsis within our hospital wards. Erysipelas, pyæmia, and hospital gangrene frustrated all surgical progress, and technical advance which had been considerable under Syme was held up by fear. "Hospitalism", defined by Erichsen as a term implying "the general morbid condition of the building or its atmosphere productive of disease", was a subject of much thought and discussion during Tait's early professional life. Papers on the subject by Sir James Simpson passed to Tait on his death and led him to a wide statistical inquiry and a paper in 1877 which caused much controversy. This investigation appeared to condemn the larger hospitals as being more dangerous than smaller units for the work of the operating surgeon. The conclusion, which was quite in keeping with much current thought, threatened a widespread change in hospital design and under Tait's influence led to the founding in Birmingham of the Women's Hospital, isolated from the general hospitals of the city. Lister's patient work, however, was producing a new school of thought which had made considerable progress both at home and abroad by the time Tait's paper appeared, and in the next few years the subject gradually died down as the Listerian principles became accepted.

Throughout his life Tait's surgery retained strong impressions derived from his associations in Edinburgh, and his work was much influenced by Syme and Simpson, with both of whom, and the latter especially, he was closely associated as a student and assistant. Edinburgh at that time was a focus which attracted the surgeons of the world to the clinics of these great teachers then at the height of their fame. At this time, too, Lister often revisited his old chief, Syme, coming over from Glasgow to see him operate on some notable case. Tait, too, specially acknowledges his indebtedness to Mackenzie Edwards and Keith, whose tentative work within the abdomen inspired his later work.

Tait's claim to fame rests upon his pioneer work within the abdomen, and it is very difficult for us, to whom a laparotomy is an everyday affair, to realize the reluctance with which surgeons overcame their fears of carrying their art into this new territory. Anaesthesia was a necessary pre-requisite, but even 35 years after its discovery intra-abdominal procedures were relatively rare and limited for the most part to disease in the pelvis such as ovariectomy and pelvic suppuration. There were many factors which held up the surgical advance within the abdomen. First and foremost was the fear of infection, a formidable obstacle in all surgery until Lister's work swept away our ignorance of the forces of sepsis, but this was not the only factor, difficulties of diagnosis were immense, and it is interesting that the ovarian cyst in which the diagnosis was reasonably obvious provided the first point of attack. Intra-abdominal work called for special techniques to deal with many surgical problems so different from those with which surgeons were accustomed to deal in the body generally. This skill could only be acquired gradually in the light of experience, often bought very dearly. In those early years the exploratory operation was only just becoming possible as sepsis was being mastered and the "pathology of the living", which later gave us such a rich harvest of intra-abdominal pathology, could only advance slowly as experience accumulated. Tait availed himself fully of both these lines of progress as his confidence in his abdominal work increased. In an address at Glasgow in 1891 on "The Principle of Exploratory and Confirmatory Incisions", he states, "In the year 1875 I formulated a proposal quite new in the department of surgery to the effect that we were entitled to open the abdomen in all cases where there was disease present which threatened life or made it a burden, for the purpose of seeing in which direction the diagnosis could be made more certain and how the line of effectual treatment could be opened up." The same view is apparent in his Hastings Essay (1873). "I am quite sure that each exploratory incision an ovariectomist makes gives him a great addition to his personal skill in diagnosis and will lessen for the future of his practice the need for such a tentative measure."

It was from the lessons learnt in dealing with the ovarian cyst that surgeons found their way to safety in dealing with other abdominal problems McDowell's first successful case of ovariectomy in 1809 and the small group of six cases which he later published in 1817 were for the time unique, later, Clay, of Manchester, introduced the operation into

Decision on these points was difficult, but in spite of increasing experience of the operators and of increasing attention to the teachings of Lister, the mortality remained in 1871 at over 25 per cent in the hands of the most experienced operators Tait's early cases were done at this time, he followed Spencer Wells, using the clamp to crush the extra-abdominal



LAWSON TAIT

Britain, doing his first case in 1842, publishing a group of 32 cases with 10 deaths in 1848 Hereafter the operation was occasionally performed, but by no means generally accepted till Spencer Wells started his great series of cases in 1858 From then onwards the operation received more widespread acceptance by the profession, though heated controversy for years waged about every technical detail This discussion was at its height when Tait was a student and continued during his early years of practice It eventually narrowed down as to how the stump should be treated Should it be brought out through the wound and crushed by clamp (Spencer Wells), be ligatured by a long ligature (McDowell and Clay) or by a short ligature (Nathan Smith), or treated by cautery (Baker Brown)

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stump, and his mortality in the first 50 cases, published in 1878, was 38 per cent in spite of using Listerian precautions in which he had but little faith Review of these cases caused him to break away from the practice of Spencer Wells and the teachings of Lister Henceforward, he ligated the stump with boiled silk and dropped it back into the abdomen and gave up the routine of Listerism and adopted methods which later became known to us as 'aseptic' These decisions involved him in bitter controversy with Spencer Wells and antagonized him to the teachings of Lister for the rest of his life He was able, however, in 1886 to publish a list of 137 consecutive ovariectomies without a death, a result which appeared to justify his change of policy

The increasing safety with which ovariectomy could now be performed and the experience gained in intraperitoneal surgery in the early cases provided the stepping stones along which general abdominal surgery advanced rapidly, and between the years 1878 and 1881 a growing confidence replaced the previous fears. During this period two notable advances were made by Tait. He performed the first cholecystotomy in Europe in 1879 and the surgery of pelvic suppuration was given a rational pathology out of experience gained by an abdominal approach which he was the first to advocate. The aetiology of pelvic suppuration had long remained obscure and was the subject of much debate for generations, and so long as treatment was confined to a timid approach through the pelvic floor or to an incision into the iliac fossæ in a late case, little progress was possible, and it was largely due to Tait's attack on inflammation within the pelvis by the abdominal route that it became clear that inflammation within the Fallopian tube was an aetiological factor of prime importance in many of these cases. As a result of his bold surgery, radical treatment and cure replaced the former timid conservatism which was often followed by prolonged illness and suffering. From the pelvis to the general abdominal cavity was a short step, but one which required a good deal of courage to take, and in 1879 Tait was the first surgeon on this side of the Atlantic deliberately and successfully to open the abdomen as an exploratory measure and, finding gall-stones, remove them and suture the gall-bladder to the parietes. It is true that to Bobbs, of Indianapolis, must go the credit for the first successful cholecystotomy, but the record of this operation was at this time unknown and was for a long time overlooked as it was published in a local medical paper and not generally available. The problem of gall-stones was much in the minds of surgeons at this period, and the theoretical considerations governing the possibilities of surgical removal had been discussed, whilst a tentative operation in two stages had been carried out successfully by Kocher, and Keen and Marion Sims had both operated, but unsuccessfully, on cases of gall-bladder disease. Five years later Tait recorded 14 cholecystotomies with 1 death and the operation by this time was being carried out by many surgeons. Ochsner, writing in 1908, says "and to Tait more than to any other surgeon of this period is due the credit of placing the surgery of the liver and gall-bladder on a firm basis."

The International Medical Congress held in London in 1881 was a meeting of great distinction under the presidency of Paget, Tait took part in many of the discussions and contributed a notable paper on recent advances in abdominal surgery based on 66 cases of abdominal section for a wide variety of conditions. The series included the first cholecystotomy, six operations for Fallopian pregnancy, several cases of hydatid of the liver treated by marsupialization, and a number of cases of pelvic infection treated either by abdominal drainage or salpingectomy. The paper was an outstanding one which placed him in the forefront of the rapidly advancing surgeons of the day—Marion Sims, in a general discussion on the papers

presented, said "Mr Lawson Tait's paper is hardly open to criticism or discussion. We have simply to accept the teachings of his experience as he has presented them."

It is impossible within the limits of a short paper to do more than touch upon the more notable surgical advances which resulted from Tait's work, but there yet remains, outstanding amongst these, the operation for ruptured ectopic gestation. Nothing illustrates the fear in which surgeons held an abdominal intervention more clearly than that this condition, so deadly, so simple in its pathology, and so amenable to operation, should have waited until 1883 before successful surgical treatment was initiated by Tait. For more than forty years it had been the subject of surgical discussion—numerous surgeons had recommended intervention but no one had actually carried it out—yet the tragedy of each of these cases slowly and almost inevitably dying of hæmorrhage had impressed itself deeply on our profession. Tait, after witnessing the death of one such case in which he was pressed to operate by the practitioner, Dr Hallwright, who was well known to me as a student, did a post-mortem examination which showed him how easy the arrest of hæmorrhage might be done, and shortly afterwards saw another case too late to save by operation. In the third case operation was successfully carried out and the new advance achieved. From this time on Tait had an accepted position in world surgery and his work in Birmingham attracted surgeons of distinction from Europe and America and extended his practice not only over the British Isles, but not infrequently to the Continent of Europe. In Europe and America his work and his writings gained him a wide renown and placed him in the front rank of British surgeons as a pioneer of abdominal surgery and a skilful and resourceful operator. His assistants carried his gynæcological teachings to the ends of the earth and included amongst others Price, of Philadelphia, whose unique place in American gynæcology enabled him to spread Tait's teachings to a wide audience across the Atlantic and secured for Tait, when he visited America in 1884, a triumphal tour to the great medical centres of the United States of America and Canada, at many of which he lectured and operated. Mayo Robson and Grieg Smith also came directly under his influence, and both played a considerable part in the development of abdominal surgery in the latter years of the last century. From Grieg Smith's book on abdominal surgery, published in 1887, "the first attempt to deal with the practical surgery of the abdomen in one Treatise", it is obvious that Tait's work was influencing surgical progress over almost the whole field of the abdomen. Another of his assistants was Stewart McKay, of Sydney, his biographer,\* to whom I am much indebted for many of my facts. In a foreword to his biography he gives two quotations which record opinions of his contemporaries as to the outstanding place which Tait occupied. "The cavities of the body were a sealed book until the father of abdominal surgery, Lawson Tait, and our own Joseph

\* *Lawson Tait His Life and Work*, 1922 London Baillière, Tindall & Cox

## ACRYLIC DISCS IN RABBITS' SKULLS

Price, carried the sense of sight into the abdominal cavity" (William J Mayo), "In pelvic surgery Tait stood first and taught us the best we know. He has had no close second, his disciples have not greatly improved upon his ways" (Joseph Price). As a craftsman Tait was very quick and dextrous and had great resource and courage. His surgical equipment was of the simplest, and he preferred to operate in the patient's bedroom on a narrow trestle table or in a small institution such as the hospital which he founded in Birmingham, or at his own nursing home where much of his pioneer work was performed. His surgical technique was copied from Syme, who relied on neatness and cleanliness of the operation field. His instruments and silk ligatures were boiled, and plenty of soap and water were used on his hands and the patient's skin. He recognized the dangers which arose to the surgeon from contacts with sepsis in the wards, the theatre, or post-mortem room—hence his desire to insulate himself from the perils of the great hospitals and work in a smaller unit. Lister's work he neither understood nor appreciated. He had found a method that suited himself and that sufficed. His success was empirical and Lister's slow scientific advance into the problems of sepsis, with his advocacy of changing surgical technique to meet problems as they unfolded themselves, prejudiced him against the whole of the Listerian doctrine after paying lip service to it in its earliest years. Hereafter, he lost no opportunity in voicing his prejudice and thus placed himself in antagonism with forces which more and more swept by him. He had, however, by chance taken a short cut which led to 'aseptic surgery', into which the extreme 'antisepticism' of Lister's early days gradually merged.

His was a dominant personality, "the power of the man held you like a vice" says one contemporary, but his strong prejudices, domineering manner, and his hard hitting in the controversial matters in which he so frequently indulged in the medical press and at professional meetings left him few friends outside the small group with which he was in immediate contact in his work. He took a challenge from the provinces to London which the leaders there resented most bitterly, not so much perhaps from what he said as in the way he said it. His bitterest opponents were Spencer Wells (once his friend and leader), Mathews Duncan, and a number of the younger school of surgeons who had accepted and appreciated the work of Lister. These qualities, however, must be integrated into the times in which he lived—something explosive was required to remove old prejudices towards the surgery of the abdomen, and his methods of controversy were only slightly more heavy handed than those which were then commonplace in medical circles. The fact remains, however, that these personalities rather overclouded his great achievements, a position which has remained to this day, not only in the city in which he did most of his life's work, but throughout Britain. On the continent of Europe and in America it is evident from contemporary literature and from the works of those who grew up under his influence that his achievements were more truly recognized and appreciated at their true perspective, and we of this generation are also sufficiently removed from his work to put it in its true perspective, and he appears as one who exercised immense influence in furthering the development of gynaecology and abdominal surgery at a moment when surgery—though on the edge of a new epoch—was temporarily held back by the forces of tradition and conservatism.

## EXPERIMENTAL SURGERY

### IMPLANTATION OF ACRYLIC-RESIN DISCS IN RABBITS' SKULLS

By DIANA J K BECK,\* DOROTHY S RUSSELL,\* J M SMALL, MAJOR, R A M C, AND M P GRAHAM, MAJOR, A D CORPS  
FROM THE NUFFIELD DEPARTMENT OF SURGERY, OXFORD, AND A MILITARY HOSPITAL FOR HEAD INJURIES

The following experiments were undertaken in order to observe the histological reactions to the implantation in rabbits' skulls of acrylic-resin discs. Admittedly the rabbit is an unsatisfactory subject for the purpose, owing to the thinness of its skull, but facilities were lacking for the use of any larger animal on an adequate scale.

#### TECHNIQUE

Under nembutal anaesthesia, supplemented when necessary with a little ether, a triangular flap of pericranium was reflected medially from the left side of the vault of the skull. An area of bone sufficient to accommodate the disc (approximately 1.4 cm in diameter) was then nibbled away to expose the dura.

Bone-wax was used when necessary to check hæmorrhage from the margins of the opening. In half of the experiments a circular piece of the exposed dura was cut away, but the leptomeninges were left undisturbed except in four instances where slight or moderate cortical trauma was accidentally inflicted. The disc of plastic was then fitted to the opening in the bone, the pericranial flap reflected and secured with a few silk stitches, and the scalp wound closed.

The discs were prepared from wax patterns, and the acrylic resin used was Kallodent (Clear), ICI Ltd. They conformed to the shape and thickness of the rabbit's skull, being slightly curved like a watch-glass. The edges were bevelled to prevent the disc from slipping beneath the surface of the bone.

\* Working for the Medical Research Council

Fibrin membrane, kindly prepared by Dr R G Macfarlane according to the method described by him (1943), was laid between the disc and the surface of the brain in four of the animals in which dura had been removed

### RESULTS

A total of sixteen animals was used. All remained well and free from infection except on one occasion when three of the four animals operated upon



FIG 76—Inner aspect of vault of skull, 2 months after operation, showing floor of capsule and rim of cut dura. No abnormality in brain

developed a local abscess containing Gram-positive cocci. Aseptic precautions were observed as closely as possible in these experiments, but, since the operations had to be done in the room in which the animals were kept, obvious opportunities for contamination existed.

The thirteen remaining rabbits of the series showed no effusion or other abnormality at the site of operation. They were killed and examined at intervals varying from one week to seven months after operation. At these times a pair of animals, with and without intact dura, was selected. The whole of the vault of the skull was removed in one piece together with the cerebral hemispheres and fixed in formaldehyde. The disc was then removed after dividing the fibrous tissue covering it. Suitable blocks were prepared in the coronal plane after decalcifying the bone in formic acid, and paraffin sections from these were stained with Ehrlich's hæmatoxylin and eosin, Weigert's iron hæmatoxylin and Van Gieson's mixture, and with phospho-tungstic-acid hæmatoxylin.

**Macroscopical Examination**—From the earliest stage (1 week) the disc was enclosed by a capsule of fibrous tissue which gained little in density with age, and at all times presented a smooth glistening inner surface from which the disc itself remained free. The dorsal part of the capsule was formed in part by the pericranial flap, with which the newly-formed fibrous tissue was blended in a continuous sheet. Over the cut margins of the

bone the surface of the fibrous tissue sloped in conformity with the bevelling of the disc and became continuous with the dura inferiorly. Where the dura had been sacrificed the gap was filled in by a layer of glistening grey tissue which only differed from the adjacent dura in being less dense. The cut margins of the dura could be clearly seen even after 4 months had elapsed (Fig 76). Fibrous adhesions in the 6-months' specimen prevented observation of this feature. At 1 month and later the floor of the capsule often appeared opaque, yellowish, and gritty from the deposition of bone within the tissue. This began at the margins, usually in an eccentric fashion, and spread towards the centre. Nevertheless, in certain instances this change was absent, even at 6 months.

The disc could often be moved slightly in its bed, but in some it was wedged firmly into the bone. Yet in all instances it could, after splitting the capsule, be levered out of position. It then slipped out easily. Its texture and appearance seemed unaltered by contact with the tissues save for a slight uneven milky opacity of its surface, due to the adherence of living cells.

**Microscopical Examination**—By the end of the first week (Fig 77) the capsule is composed of circumferentially arranged spindle fibroblasts separated by delicate collagenous fibrils. Towards its inner surface the interstices are sometimes filled with laked red corpuscles, and a little fibrin separates the capsule from the disc. There is an increase of spindle fibroblasts in the superficial aspect of the dura beneath the disc and, where a gap in the dura had been made, the deficit is filled by a sheet of similar fibroblasts. This basal layer of fibroblasts

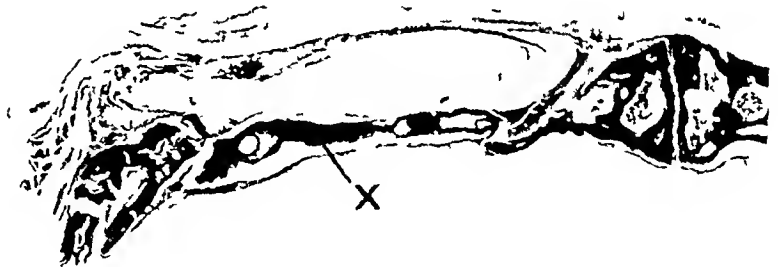


FIG 77—Site of graft 1 week after operation. Fibrin membrane (X) in floor of capsule. Hæmatoxylin and eosin ( $\times 65$ )

is continuous laterally with the endosteum of the adjacent bone. Here there is great osteoblastic activity and new bone is being laid down in the wedges of young fibrous tissue that conform to the bevelled edges of the disc. An increase in number and size of the osteoblasts over the inner and outer tables of the skull extends for a distance of 1 cm from the margins of the bony deficit.

At 1 month the picture is similar, but the cellularity of the capsule has diminished, especially in the dorsal wall (Fig 78). The inner surface is lined with a few large mononuclear cells of irregular outline. The floor of the capsule is composed of a vascular fibrous tissue which appears distinct from,

though continuous with, the subjacent dura and is clearly blended with the endosteum laterally. It bridges the gap between the still identifiable cut edges of the dura. Laterally it contains trabeculae of lamellar and, in places, coarse-woven bone.

As already noticed, opacities were observed macroscopically on the surfaces of the disc, due to the presence of cells. These were examined microscopically by washing the disc in distilled water, staining it for a few minutes in 1 per cent toluidin



FIG 78—Site of graft 1 month after operation. Dura sacrificed. Adhesions between capsule and leptomeninges. Brain normal. Haematoxylin and van Gieson ( $\times 65$ )

But in the three animals killed at this period the degree of bone-formation varies. In two (one with intact dura) it is slight and confined to the margins, while in the third (dura intact) the whole floor except the central 1.8 mm is ossified.

At later stages, up to 7 months, there is little further change. The collagenous fibres of the capsule become coarser, with concomitant decrease

blue, and, after further washing, placing it upon a glass slide. The transparency of the disc permitted the use of all objectives, including the  $\times 1$  in oil-immersion lens, for examination of the surface placed uppermost. Numerous cells, often in groups, were observed in all the experiments. After two weeks they were mainly polymorphic cells, some of which resembled fibroblasts while others, including many



FIG 79—Site of graft 2 months after operation. Dura intact. Ossification of greater part of floor of capsule. Haematoxylin and van Gieson ( $\times 65$ )

of cellularity. Occasional flattened cells are present on the inner surface, but there is no definite cellular lining. Ossification (Fig 79) is confined to the basal part of the capsule and in general tends to increase with time, but it is inconstant and was absent in one of the rabbits killed at 6 months. It appears to be unrelated to the presence or absence of dura. Local osteoblastic activity gradually subsides leaving evidence of architectural reconstruction of the neighbouring skull. This is somewhat expanded, forming a buttress about the disc. The medullary spaces are enlarged and there is in places a mosaic appearance of the Haversian systems of the lamellae.

small multinucleate giant-cells, contained ingested red corpuscles and were clearly macrophages. In addition there were groups of cells resembling small lymphocytes, and numerous free red corpuscles. At later stages the red corpuscles had disappeared and the macrophages often formed large syncytial masses.

Other cells, indistinguishable from fibroblasts, were also numerous. Both surfaces bore all types of cells, but, on the whole, the lower concave surface had a richer growth than the upper, which, being convex, came into close opposition with the capsule.

The brain and leptomeninges appeared perfectly normal in all rabbits where the dura had been preserved. In 4 out of the 7 animals in which the dura had been sacrificed or torn (one animal) delicate fibrous adhesions were present between the fibrous tissue of the capsule and the leptomeninges over one small area. In 3 of these 4 the superficial cortex had been stabbed beneath that area, leaving a narrow tapering scar of glia and connective tissue. There remained 3 animals in which removal of the dura was not followed by the formation of adhesions. In one of these, killed after one week, the cortex

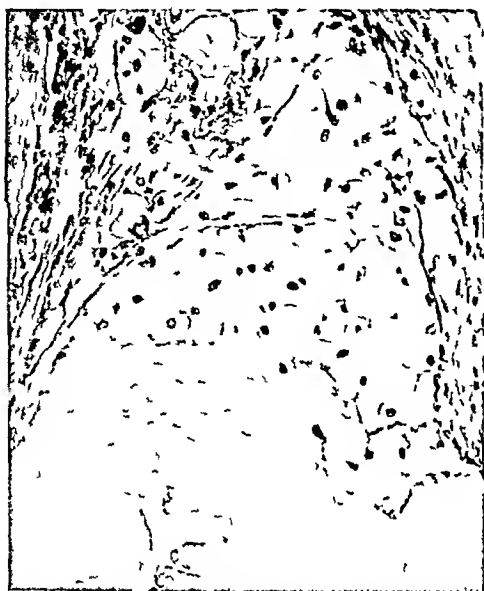


FIG 80—Phagocytic mononuclear cells in border of fibrin membrane 1 month after operation. Phosphotungstic-acid haematoxylin ( $\times 200$ )

had also been superficially stabbed, and it may be assumed that adhesions would have formed here had survival been longer.

*Fibrin membrane* was used to form a layer between the disc and the surface of the brain in 4 of the animals in which dura had been removed. Unfortunately two of these animals were in the batch that became infected. The remaining two were killed after 1 and 4 weeks respectively. Delicate fibrous adhesions were present between the surface of the brain and the floor of the capsule in the 4-weeks' specimen. At 1 week the fibrin shows a border of macrophages from 1 to 2 cells deep, in places they have fused to form foreign-body giant-cells. At 4 weeks the fibrin has been broken up into small masses and incorporated in the fibrous tissue forming the floor of the capsule. Much of it has been replaced by solid masses of large polygonal cells with granular eosinophil cytoplasm (Fig 80). With the polariscope this granularity is found to be due in part to the presence of numerous doubly-refractive acicular and elongated hexagonal crystals of varying size. The fibrin in two of the infected animals, dying after 6 and 12 days respectively, contains many similar but smaller crystals, but none could be seen in the uninfected animal killed after 1 week.

## DISCUSSION

Study of the histological reactions that follow the implantation of acrylic-resin discs into the rabbit's skull indicates that this substance may also be suitable for the repair of defects in the human skull. The plastic, as expected, excites a foreign-body reaction and thus its surfaces become coated with large numbers of macrophages. The abundance of these cells, together with fibroblasts, in this situation shows that the plastic is not obviously cytotoxic. Nor are there any demonstrable histological effects upon the adjacent cortex. As the experiments have shown, the disc rapidly becomes encapsulated by fibrous tissue from which, however, it remains detached. The dura at its base remains relatively inert and the capsule here is formed by the activity of the adjacent endosteum. Hence it is not surprising that bone is frequently laid down in this basal part, though this was inconstant in our series and the factor, or factors, controlling it undetermined. The superficial part of the capsule is derived from the pericranium and, in these rabbits, never showed any trace of ossification. Operative defects in the dura were closed, not by any outgrowth from the dura itself, but by the fibrous tissue derived from the endosteum. These stages in healing are complete in the rabbit at about the fourth week after operation, and only minor changes occur subsequently.

Where the dura had been left intact no adhesions formed between it and the underlying brain. Where the dura had been removed fibrous adhesions might form between the capsule and the leptomeninges, and this probability seemed to be greatly increased when the cortex was damaged.

## SUMMARY

- 1 The histological reactions to the implantation of acrylic-resin discs in rabbits' skulls were observed in a series of experiments, in half of which the dura was sacrificed at the site of the cranial defect.

- 2 The disc became encapsulated by fibrous tissue from which, however, the disc itself remained free.

- 3 The basal part of the capsule was formed from the adjacent endosteum, which also repaired the gap in the dura.

- 4 The growth of cells upon the surfaces of the disc demonstrated the absence of cytotoxic properties on the part of the acrylic resin.

- 5 Sacrifice of the dura, and injury to the subjacent brain, were sometimes associated with the presence of adhesions between the capsule and the leptomeninges. No adhesions formed when the dura was intact.

Our thanks are due to Prof J A Gunn for providing accommodation for the animals. The expenses were defrayed by a special grant from the Medical Research Council.

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## In Memoriam

### HAROLD COLLINSON

(1876—1945)

THE death of Harold Collinson took place at his home at Linton, near Leeds, in January of this year. He was 68. Spending a very full life, he was spared a long illness and was at work till within a few weeks of his death.

Collinson qualified from the Leeds Medical School in 1899, took the F R C S in 1903, and M S, London, in 1907. He held resident surgical posts at the General Infirmary at Leeds and was appointed to the Staff as Assistant Surgeon in 1907, promotion to the full staff coming at the end of the last war. On the academic side he was in turn Leeds University clinical lecturer, Professor of Clinical Surgery (1927-33) and Professor of Surgery (1933-6). On returning from the active staff of the Infirmary and University at 60, he became Dean of the Medical School and represented the University on the General Medical Council. In both posts he did admirable work and his clinical outlook and training proved of great value. The high regard held of him by the Council was shown by his appointment to inspect and report on the final examinations in surgery of the British Universities and examining bodies. This was work he greatly enjoyed and he was able to complete it just before his death.

No account of Harold Collinson would be complete without reference to his military career. He joined the Territorial Army in 1905 and was mobilized at the outbreak of war in 1914. He served abroad from 1915 till 1918, becoming A D M S, 62nd (W R) Division, attaining the rank of Colonel. The list of his military honours is some indication of his distinguished service, D S O in 1917, C M G in 1918, and C B in 1919 and Chevalier of the Legion of Honour.

The war had considerable effect on Collinson's surgical practice and it took him some time to pick up the threads again. He never regretted the experiences he gained during these war years and the many friends and contacts he made. At the outbreak of the present war he was appointed Group Officer for the Yorkshire area under the Emergency Medical Service and also Regional Advisor in Surgery.

Collinson took a large share in the many activities which are inherent in a great general hospital. He was Chairman of the Medical Faculty for a number of years, and Chairman of the Nurses' Education Committee and of the Radium Committee of the General Infirmary.

He had many interests outside his profession. For a number of years he was a keen member of

the Branham Moor Hunt, was active in the Boy Scout Movement, and in later years an enthusiastic fisherman.

These are some of the things Collinson did. It is less easy to portray what a fine man he was. Honest and sincere, no one could ever doubt his



HAROLD COLLINSON

1876—1945

absolute integrity. There was no meanness in his soul and he always saw the best in others. He loved his fellow men and they in their turn loved him. True, he did not reach pre-eminence in the surgical world, but he was a sound surgeon well known and greatly respected over a wide area of Yorkshire. He was very popular with his students, an able teacher, many generations of undergraduates must have benefited by his learning and experience.

He leaves a widow, a son who is in practice, and two daughters.

## VISITS TO WAR CLINICS

THE 'SPINE UNIT', MINISTRY OF PENSIONS HOSPITAL,  
STOKE MANDEVILLE

ANYONE who recalls the picture of the Lioness of Nineveh, with spinal cord transfixed by an arrow, dragging herself by the forelegs, in a supreme effort to reach her enemy, must sympathize with the soldier who, in the heat and height of battle, is struck through the spine and lies paralysed.

Recollections from the last war of cases of spinal injury have left unpleasant memories of hopeless

opinion this fact is largely responsible for the improvement in the health and well-being of the patients.

The third approach is the combat against bed-sores. The fight has been won, but it is still on and has to be waged with constant unremitting vigilance. Almost every patient who comes in has a bed-sore, some of them literally as big as soup plates, even these become healed.

Work such as this means the expenditure of much thought and energy. Individual care is demanded of the medical officer, the nursing sisters, and, by no means least, the orderlies. A 'Spine Unit' in fact requires a larger ratio of workers to patients than any other type of ward because there is so much detail work to be done.

The medical officer in charge of this ward is Dr L. Guttman, who spends the whole of his time and lavishes all his care and thought on his patients. The picture showing the men playing polo in wheel chairs (Fig 83) indicates his ingenuity in providing occupation and amusement.

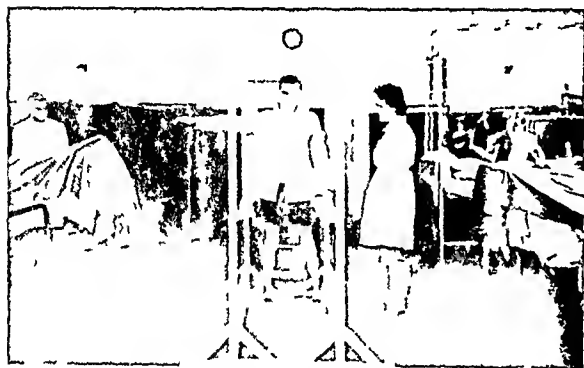


FIG 81—Walking exercises in parallel bars (improvised from Balkan beams)

helplessness, of sores, and of smells, and it was with some such mental picture that one entered the 'Spine Unit' at Stoke Mandeville.

These thoughts were quickly brushed aside by the brisk and purposeful air that pervaded the ward. The atmosphere was cheerful and the patients were bright and of a good colour. They were all busy, either writing or reading, doing embroidery, or making string belts. Their state was good, they had been lifted right out of the dominance of urinary infection and of bed-sores. This happy result has been brought about in three main ways. The first and most important approach is the psychological. Immediately on arrival the patient is assured that because he is paralysed it does not mean that life is finished and that he will never be able to do anything again. Before him he sees men, similarly afflicted, but bright and cheerful, sharing in the communal work of the ward and some actually going daily from the ward to do work in a nearby factory. This visible proof of recuperation is of the highest value in convincing the man of the truth of what he is being told. It proves that hope is not vain and that help is to hand.

The second approach is by reducing urinary infection. This has been brought about by suprapubic and tidal drainage, which is applied to practically every patient (see Fig 84). This tidal drainage is an advance on any routine method previously in use and though urinary infection is not thereby abolished, it is kept in control. In the writer's

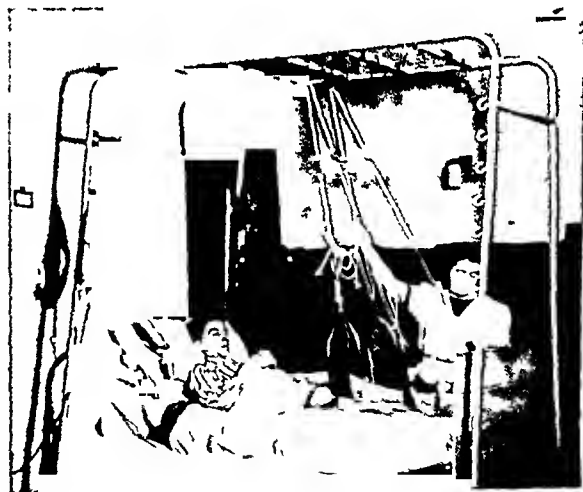


FIG 82—Shing exercise in a cauda equina lesion in a spinal ward

The surgery and the management of the bladder and the whole policy of urinary protection is under the direction of Mr E. W. Riches, M.C. This work is all-important, for, unless urinary infection is controlled, other precautions would be in vain.

So much for the directly medical and physical aspect of the problem. There is still something more to be done to prevent these men from being cast on the human scrap-heap. It is not enough just to pension them and think that our duty and indebtedness to them is thereby discharged. What they crave for is to get back into the world of work in some way or another. It is all very well to keep

a man amused for a time with embroidering regimental badges or making string belts, but that is not enough. Every effort should be made to secure for each disabled man some place in industry. As the Minister of Labour, Mr Ernest Bevin, said "If a man becomes a master of a craft he masters

self-reliability amongst them, and give them the biggest possible sense of self-assurance that we can (2) To instill into them the feeling that, although they are crippled, they are just as good at certain occupations as the man who is not."



FIG 83—*Wheel-chair polo* This game can be played by any number of patients. It is played with short polo sticks adapted to the height of the wheel chairs, and a wooden disc is used instead of a ball.

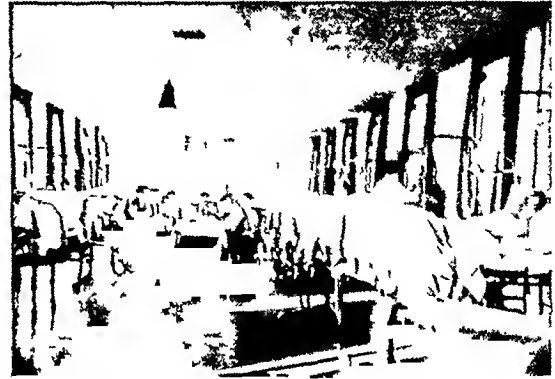


FIG 84—General view of a spinal ward, showing apparatus for tidal drainage.

his disability." This may sound a difficult thing to do, but a beginning has been made at Stoke Mandeville and it is working well.

The Medical Superintendent, Major-General Blake, has kindly described the arrangements which are being made to introduce vocational training—

At the present time there are actually six patients in this unit who are going out to work. The men leave the hospital by ambulance and are taken to a factory (The Ecco Factory, Aylesbury) where they work for two hours and a half, after which they return to hospital. It is reported that none of the men

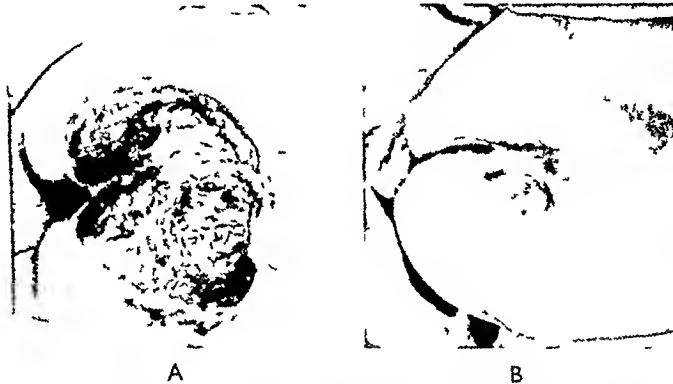


FIG 85—Gunshot injury of the spinal cord in the mid thoracic region, with complete transverse lesion showing an enormous bed sore. A, Photograph taken on Aug 1, 1944, after excision of the slough; B, Photograph taken on Jan 22, 1945, about three weeks after complete healing.

as distinguished from occupational training—into the hospital wards, at an early stage in the treatment of patients. The following extract from one of his reports shows what is being aimed at—

"From study of patients in hospital, the fact that a man is paralysed and loses the use of his legs seems to sharpen his wits and make him more mentally active, and this fact should be borne in mind when selecting vocational training and trades for these men. The intention of introducing vocational training is, if possible (1) To foster

who have been out to work have come to any harm, and all seem to be the better for it and their mental outlook improved.

Arrangements have been made so that the men get some pay for the work they do. This helps, too, and, as was said before, the sight of patients in the wards actually going out to work is a stimulus and comfort for the new patient. Here, then, is the beginning of team work of the best kind between three Ministries, those of Health, Pensions, and Labour. A hopeful sign!

## SHORT NOTES OF RARE OR OBSCURE CASES

## FATIGUE FRACTURE

BY A RONALD, WING COMMANDER, R A F V R

CONSIDERABLE interest has been shown in this condition during the past two years and numerous cases have been already published. In February of this year a patient with bilateral fatigue fractures of the fibula came under my care and as far as I know no example of the bilateral symmetrical lesion has been published in this country. A case in America has recently been published by A. Scott Hamilton and H. E. Finklestein (1944).

## CASE REPORT

**HISTORY**—In a cross-country run the patient had got within twenty yards of the finishing post when, on attempting to lengthen his stride, he felt a severe pain

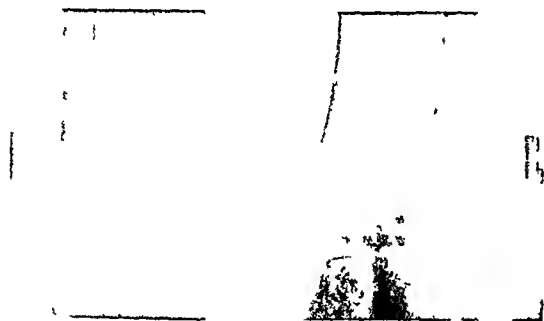


Fig 86—Radiograph at twelfth week.

in his left ankle and fell to the ground. Although he had considerable pain the next day he continued at his work, reporting sick each day and having applications of lin. meth. sal.

*Two weeks later*, because of the continuing pain, he was X-rayed. The radiograph was said to show no bony injury. He was then treated by radiant heat and massage.

*Four weeks later*, because no relief had been obtained, he was referred to the Orthopaedic Department.

**ON EXAMINATION**—He localized his pain to a point some 2½ in. above the external malleolus, and palpation

of this area revealed a fusiform swelling of the fibula. Radiography showed considerable new-bone formation in this region typical of so-called 'fatigue fracture'.

Re-examination of the radiograph taken two weeks previously showed a crack running through almost half the thickness of the fibula. He also complained that for almost the same length of time he had had pain of lesser intensity in the right ankle, at almost exactly the same level. This was explained to him by the Unit Medical Officer as being due to the strain of walking with the greater part of his weight on the right ankle. Examination showed local tenderness but no thickening of the fibula. Radiography showed very early changes of fatigue fracture.

## PROGRESS—

*Tenth week*. Reported to the Orthopaedic Department. Radiograph of the left leg shows calcification of the callus proceeding and union almost complete.

Examination of the right leg showed a slight fusiform swelling and a radiograph showed a little new-bone formation on the posterolateral aspect of the fibula. Patient continued on light duties.

*Twelfth week*. Reported again to the Orthopaedic Department. Pain diminishing—radiograph of left leg shows that consolidation is taking place. Right leg shows callus well calcified (Fig 86).

*Sixteenth week*. Now free from the original type of pain, although during the past week, owing to a change of his duties, he has had to stand a great deal and has experienced a burning type of pain at the fracture site.

*Left leg*. Fusiform swelling has diminished in size and the leg is free from tenderness. A radiograph shows the fracture soundly united.

*Right leg*. Merest trace of a ridge at the site of the fracture. Very slight local tenderness. Radiography shows fracture soundly united.

A comprehensive review of "fatigue fractures" has been given by J. Blair Hartley (1943).

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## RECONSTRUCTION OF A COMMON BILE-DUCT DESTROYED IN A MILITARY WOUND

BY SIR JAMES WALTON

ALTHOUGH of recent years accidental injury of the common bile-duct has become so relatively frequent that I have been able to publish a series of 46 cases in which I have had to perform a reconstruction (1942), most of these cases were surgical mishaps occurring during the operation of cholecystectomy. Examples of recovery after injury from military wounds are of extreme rarity and this of necessity

so, for any penetrating wound, whether due to a rifle bullet, a fragment of bomb casing, or a bayonet-thrust which injures the duct is likely at the same time to perforate the hepatic artery, the portal vein, or the inferior vena cava, and so lead to a fatal hæmorrhage.

The only successful case with which I am conversant is that published by Park (1943). In

# BURNING AND POISONING BY METHYL BROMIDE

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his survey he states that no specific case was reported by Sir Cuthbert Wallace in his review of the abdominal injuries in the last war, but he mentions one case in the last war and two in this where the duct might possibly have been injured. In his case the duct was found to be divided at an operation performed nineteen hours after the injury. The proximal end could not be found and the wound was drained. The patient later developed obstructive jaundice and cholangitis. At a second operation, nearly four months after the injury, an end-to-end suture of the duct was performed with a successful result.

## CASE REPORT

The present case is that of a young soldier (G W S, aged 20) who was in his camp in Southern England on June 29 when a flying bomb fell 20 ft from where he was standing. He was admitted to a military hospital under the care of Lieut-Col F N Foster, to whose detailed and careful notes I am indebted for the following resume. He showed multiple dirty wounds and was very shocked, but he improved with resuscitation treatment. The radiographs showed multiple foreign bodies in the chest wall, with blast changes in both lungs and several foreign bodies in the right side of the abdomen, the right knee, and the left arm.

At operation a penetrating wound of the sole of the right foot was found, with large wounds of the right thigh involving the whole depth of the quadriceps, an extensive wound of the left thigh with a large retained foreign body, and numerous wounds of the back, both arms, and forearms. All wounds were surgically cleaned and dressed. Subsequently his condition was, for a time, very poor, but the notes showed that he was given the most meticulous care and attention. M & B and sera were administered, frequent cultures of the wound were taken, and, under their control, treatment with penicillin instituted. Soon after the operation he began to vomit and on the second day there was tenderness and discomfort over the liver area. On the ninth day the wounds were clean, but he developed diarrhoea. On the thirteenth day there was more vomiting, with fullness in the right flank and upper quadrant of the abdomen. On the sixteenth day a right upper paramedian incision was made and a large collection of bile found with many adhesions. Drains were inserted into the right kidney pouch and above the pelves into the pelvis. A further study of the radiographs revealed a small fragment of metal in the region of the common duct.

On July 21 the paramedian incision was healed, as were many of the wounds on the limbs, some of which had been treated by secondary suture, but all his bile was draining through the suprapubic wound. On Sept 12 jaundice was noticed for the first time.

On Sept 18 Lieut-Col Foster was posted abroad, and by the kind offices of Brigadier Donald, who was consultant to the SE Command, the patient was transferred to me at the London Hospital Examination

showed a small rather poorly developed man who was in a good state of general health with all his wounds nearly healed. There was slight jaundice with a profuse discharge of bile from the suprapubic wound and complete absence of bile in the stools. His Hb was 98 per cent.

At operation on Sept 22 an upper right paramedian incision was made and a large cavity found below the liver, external to the duodenum and above the colon. This contained much bile, pus, and soft pigment calculi. From it fistulous tracts ran down into the pelvis and across the abdomen in front of the stomach. The duodenum, which formed part of the abscess wall, was covered in granulation tissue. The gall-bladder was collapsed and empty. After considerable dissection the common hepatic duct was found, moderately dilated, being replaced by an impervious fibrous band. The cystic duct joined the upper end of this fibrous band, and the gall-bladder was therefore removed. On opening the dilated duct a perforation was found on its posterolateral wall, but the small fragment of bomb casing could not be found. It was decided to reconstruct the common bile-duct by my usual flap method (1915, 1944), but owing to the condition of the duodenal wall this structure could not be used. The dilated duct was cut across in its lower end and its posterior wall sutured to the stomach. A flap of the whole thickness of the stomach wall was turned down and the upper end of the resulting opening sutured into the duct and below into the remaining opening of the stomach, about 4 in passing into the stomach cavity. The flap of stomach wall was now sutured over the tube side of the tube thus forming a new duct with a mucosal lining and a valvular opening into the stomach.

He stood the operation well and beyond a slight cough for a few days made an uninterrupted convalescence. There was no bile leakage, and on the third day he passed a normal-coloured stool. Four weeks after operation all jaundice had disappeared, the suprapubic fistula had closed, the paramedian incision had firmly healed, and the stools continued of a normal colour. He was up and walking about with no pain and was taking a full diet. The passage of the tube had not been noticed, but a radiograph failed to reveal its presence so that it had certainly been passed. On Nov 22 he was free of all symptoms and was 'medically boarded'. My only regret is that Lieut-Col Foster, to whose skill, care, and attention the patient undoubtedly owes his life, was, owing to the exigencies of war, robbed of the satisfaction of completing the cure.

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WALTON, Sir JAMES (1915), *Surg Gynec Obstet*, 21, 269  
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# A CASE OF BURNING AND SLIGHT POISONING BY METHYL BROMIDE

By G RUSSELL THOMSON  
SURGICAL REGISTRAR, WESTERN INFIRMARY, GLASGOW

## CASE REPORT

HISTORY—A man, aged 51 years, was admitted to the Western Infirmary, Glasgow, on Nov 25, 1943. With two other men he was working in the engine-room

of a petrol-driven barge, when a fire-extinguisher containing methyl bromide went off without warning and emitted a jet of clear fluid with a sickly smell. The fluid vaporized and gravitated slowly to the floor, where the patient was kneeling. He was wearing tightly laced,

waterproof boots which extended to just below the knee. The boots were overlapped by dungarees, and he had thick stockings beneath. Some of the fluid splashed his face and he wiped it off with his hands.

He continued working in the engine-room for over three hours, and experienced no symptoms whatever, although one of his mates felt sick. On his arrival home, some eight hours after the contact with the methyl bromide, his rubber boots felt tight and he changed into fresh socks and shoes. There was no noticeable

showed the presence of numerous polymorphonuclear leucocytes.

The two burnt areas were treated with tulle gras and sulphanilamide powder.

**PROGRESS**—For four days following operation the general symptoms were intensified and he experienced sickness and frequent vomiting. The weakness and dizziness persisted and he also suffered from sleeplessness, headaches, pains in back and limbs, and cold sweats. Both temperature and pulse were elevated throughout



FIG 87—Showing the marked blistering of the feet caused by methyl-bromide burning



FIG 88—Showing healing 14 days after

swelling nor any abnormal sensation at this period. He went to the pictures, and after a while began to feel the dorsum of each foot tingling, painful, and swollen. He walked home with great difficulty and was obliged to cut off his trousers and socks to remove them. The dorsum of each foot was badly blistered. No similar symptoms were referable to his face.

Twenty-four hours after contact with the methyl bromide he was admitted to hospital complaining of the following symptoms. His feet were tingling and intensely painful. He was feeling weak and dizzy, but at this stage was neither feeling sick nor in any abdominal pain.

#### ON EXAMINATION—

**Local Condition**—On the dorsum of each foot there was a large blister extending from the ankle to the dorsum of the toes and from the junction of the shin with the thick skin on either side. Each blister was outlined by a thin erythematous zone (Fig 87).

**General Examination**—The patient was well nourished and well developed. He looked ill and toxic, and was obviously suffering a great deal of pain from his feet. The outstanding feature of his appearance was the marked degree of cyanosis present. Examination of the heart, lungs, and abdomen was negative. Pulse, 72; temperature, 96°; respiration, 20.

**OPERATION**—Under general anaesthesia, both affected areas were thoroughly cleansed with soap and water. Out of interest's sake, the blisters were aspirated, and, from each,  $\frac{1}{2}$  pint of straw-coloured fluid was obtained. The blisters were then snipped away.

Cultures of the raw areas revealed an abundant growth of *Staph. albus*, and examination of the blister fluid

this period, the temperature reaching 103° and the pulse 116. The cyanosis became intense on the day after operation and then diminished gradually. With the disappearance of these toxic manifestations his general condition improved. The burnt areas healed well in 21 days, although a good deal of pain was present in the early stages.

### COMMENTS

Several features, both obscure and interesting, are worthy of special note.

1 The explanation as to how the burns were produced is not clear. Why were the well-protected feet the site of blistering and not the face, which actually came in contact with the vapour?

2 This type of burn is characterized by a delay of eight hours before symptoms become manifest.

3 The symptoms are both general and local—the former being characteristic of a severe toxæmia and the latter consisting of intense pain and severe blistering. The cyanosis is an outstanding feature.

4 The case illustrates the great quantity of fluid which may be lost in burns of the second degree type.

5 Examination of the blister fluid and the raw surfaces showed neither to be sterile.

I wish to thank Mr. James Fleming for permission to publish this case.

# ENCYSTED ADENOMA OF THE HEAD OF THE PANCREAS

By B T ROSE, BIRMINGHAM

## CASE REPORT

**HISTORY**—A woman, aged 39 years, was admitted to hospital with a painless swelling just to the right of the midline and above the umbilicus which she had noted for three months. The stomach was above and to the left, with the transverse colon below.

A diagnosis of retroperitoneal sarcoma was made.

**OPERATIVE FINDINGS**—A localized encapsulated tumour the size of a grape-fruit was found attached to the pancreatic head, with the duodenal loop stretched and flattened round the tumour. Careful dissection separated the duodenal loop off the tumour. Separation from the pancreatic head was associated with considerable hæmorrhage and slight damage to some of the superficial pancreatic lobules. The abdomen was closed with drainage down to the pancreatic head.

Convalescence was stormy with a small pancreatic fistula for three weeks, after which healing occurred. The patient remains well after six months.

Microscopical examination revealed a simple adenomatous structure.

I am indebted to Mr W J Pardoe, of Birmingham, for the illustration.



FIG 89—Section through the tumour ( $\times \frac{1}{2}$ )

# VOLVULUS OF THE STOMACH

By B T ROSE, BIRMINGHAM

## CASE REPORT

**HISTORY**—L G, a painter 39 years of age, complained of attacks of severe epigastric pain lasting about a week and occurring every three or four months over a period

amount of lead in the 24-hr urine never rose above 0.2 mg, even after a provocative dose of 40 units of parathormone.

A barium meal showed a rather dilated stomach with a deformed duodenal cap which was suggestive of ulcer.

Fortunately, while in hospital he developed an acute attack of pain, and a barium meal revealed a most unusual appearance (Fig 90). The stomach appeared to be divided into two sacs by a medial constriction, the duodenal deformity being still present. A further X-ray examination a week later again showed merely a large stomach with a deformed duodenal cap. At his own request, the patient was discharged from hospital, but was re-admitted nine months later. Over this interval he had four severe attacks of pain. The pain had become much more severe and each attack had lasted for 48 hours. The radiographic appearance of his stomach showed the large stomach with deformed cap as before. A tentative diagnosis of volvulus of the stomach was made and laparotomy decided upon.

**OPERATIVE FINDINGS**—There was a rope-like adhesion fixing the lesser curve of the stomach to the anterior abdominal wall in the region of the falciform ligament. The greater curve was adherent to the transverse colon at a point diametrically opposite the first band (Fig 91). The stomach was dilated both proximally and distally to these adhesions, which formed an axis around which the two portions of the stomach could rotate. Marked cicatricial stenosis of the pylorus was also present.

**Comment**—The impression gained was that overloading of the proximal and distal pouches would cause rotation around this axis, giving rise to a folding of the stomach (Fig 92). This would explain the appearance shown on the opaque meal taken during a severe attack of pain.



FIG 90—Radiograph showing the stomach apparently divided into two sacs and also the deformed duodenal cap

of twelve years. The pain bore no relation to food and was relieved by alkalis. He vomited occasionally during the attacks.

The fractional test-meal was normal and investigation of the blood revealed no punctate basophilia. The



Histological examination of the stomach and adhesions revealed no ulcer and no signs of malignancy  
A complete recovery has ensued



FIG 91—The operation findings, showing the two bands, one fixing the lesser curvature to the abdominal wall, the other the greater curvature to the transverse colon

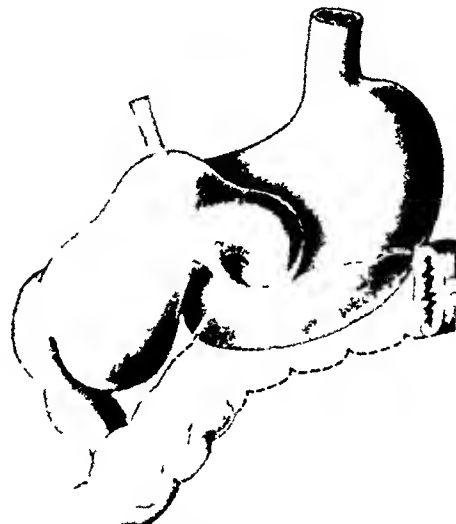


FIG 92—Drawing showing the suggested folding of the stomach giving rise to the appearance seen on radiography

A partial gastrectomy was performed, the line of section being above the level of the adhesions

Examination of the portions of the stomach removed showed an extreme degree of pyloric stenosis

I am indebted to my colleague, Dr A P Thomson, for this case, to my house surgeon, Mr Ian McNab, for his help with the notes and sketches, and to Mr W J Pardoe for the coloured drawing

## DOUBLE INTUSSUSCEPTION FOLLOWING MULTIPLE POLYPOSIS OF THE SMALL INTESTINE

By P H BEALES

SURGEON, ESSEX COUNTY HOSPITAL, WANSTEAD

AND E FRANKEL

PHYSICIAN, ESSEX COUNTY HOSPITAL, WANSTEAD

MULTIPLE polyposis of the small intestine is a rare condition giving rise to vague symptoms and the diagnosis is often missed. Such patients complain of periodic attacks of severe colicky abdominal pain accompanied by vomiting. They become anæmic, lose weight, and may have occasional mæna. During the attacks of pain an abdominal mass, usually due to an intussusception, may be palpable. The obscure nature of the symptoms may suggest gall-stone or renal colic or peptic ulcer, and as roentgenological investigations are often negative, these patients are thought to be suffering from functional dyspepsia. The following case is a good illustration of this condition.

### CASE REPORT

**HISTORY**—The patient was a young woman, aged 30. For the last thirteen years she had had repeated severe attacks of upper abdominal pain. At first she had one

attack every six to nine months, but during the last five years they became more frequent. An attack usually woke her early in the morning. The pain was of colicky nature and was accompanied by nausea and vomiting. Sometimes one attack was followed by another and she usually felt sick for two to three days. In between these attacks she felt well. The pain was not related to food. During the last thirteen years she saw many doctors and had repeated investigations of her gastro-intestinal tract, which were all negative, and as a result of this, she was thought to be suffering from a neurosis and received psychological treatment, without much improvement in her condition. The patient was very definite about the severity of these attacks, which made her life a misery.

**ON ADMISSION**—She was admitted to this hospital on Dec 24, 1944, having had a severe attack of abdominal pain accompanied by vomiting five days previously. No abnormal physical signs were found on examination. A barium meal did not reveal any organic lesion in the stomach or duodenum, but one loop of the jejunum was

# BENIGN GIANT-CELLED TUMOUR OF TENDON-SHEATH 95

found to be distended and there was a large collection of barium in the small bowel. A blood-count showed red blood-cells 3,400,000, haemoglobin 45 per cent, colour index 0.66, white blood-cells 8000. A test-meal was normal, but a test for occult blood in the stools was strongly positive.

On Jan 4, 1945, the patient had another severe attack of colicky abdominal pain. This persisted and the patient vomited a great deal. Her abdomen gradually became distended, peristalsis was marked, and a sausage-shaped mass was felt in the left lower abdomen. A

The patient made a satisfactory recovery from this operation, but had two mild attacks of colicky abdominal pain two weeks after the operation, similar to the attacks she had had before.

**SECOND OPERATION**—On Feb 15 a further laparotomy was performed and the piece of jejunum containing the adenomatous polyps felt at the first operation (Fig 94) was resected with end-to-end anastomosis.

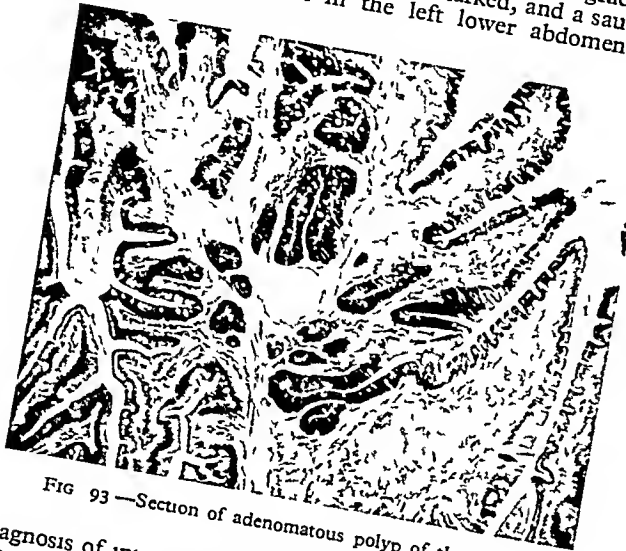


FIG 93—Section of adenomatous polyp of the ileum



FIG 94—Photograph of portion of jejunum removed at second operation, showing the adenomatous polyps

diagnosis of intestinal obstruction due to intussusception was made and laparotomy was performed.

**FIRST OPERATION**—This revealed intussusception of the jejunum starting about 10 in below the duodeno-jejunal flexure. It was reduced easily. Masses of soft polypoid material could be felt through the bowel wall. Further exploration revealed intussusception in the lower part of the ileum. This was reduced and was found to be caused by a sessile polyp about 1 in in diameter almost occluding the lumen of the bowel. The bowel proximal to the tumour was greatly hypertrophied and distended. An immediate resection of 8 in of ileum containing the polyp with side-to-side anastomosis was performed in view of the obstruction of the intestine by the tumour. It was not thought advisable to remove the jejunal polyps at this operation on account of the weak condition of the patient. The affected segment of the ileum showed a single sessile tumour arising from the mucous membrane.

Microscopical examination showed an adenomatous polyp of the small intestine. The mucosa in the polyp was of small-intestine type and contained villi. The epithelium was more cellular than is normal, but there was no evidence of malignancy. The stroma showed chronic pyogenic inflammation (Fig 93).

She was discharged from hospital 21 days later. Blood-count before discharge showed red blood-cells 4,700,000, haemoglobin 82 per cent, colour index, 0.87, white blood-cells 8800. She had gained weight and her general condition was greatly improved.

**Comment**—This case illustrates that neoplasm of the small intestine must be considered in any patient with repeated episodes of partial or complete obstruction of the small bowel and melaena, in the absence of an easily demonstrable lesion in the upper gastro-intestinal tract or colon. The course of this disease is quite characteristic and should not be confused with a functional dyspepsia.

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# BENIGN GIANT-CELLED TUMOUR OF TENDON-SHEATH

By E HAMBLY AND E SEAL  
 ROYAL NATIONAL ORTHOPÆDIC HOSPITAL, LONDON

## CASE REPORT

THE patient was a nurse aged 22. Her complaint was that she had noticed an indefinite swelling, associated with a mild aching pain, in the front of the sole of her foot. This had been troubling her for nine months.

**ON EXAMINATION**—There was a very indefinite grape-like swelling in the region of the anterior arch. The skin was stretched very thinly over the lobulated swelling, which measured 5 cm  $\times$  2½ cm. The swelling appeared to fluctuate in both planes at right angles to each other. The diagnosis was not apparent.

AT OPERATION—The tumour was found to be encapsulated and to arise from the sheath of the tendon of flexor digitorum longus of the third toe. This was photographed (Fig 95) and excised.

composed of fused nodules varying in size from a few centimetres to one centimetre. On section, the nodules are composed of firm greyish-white tissue with scattered bright orange areas.

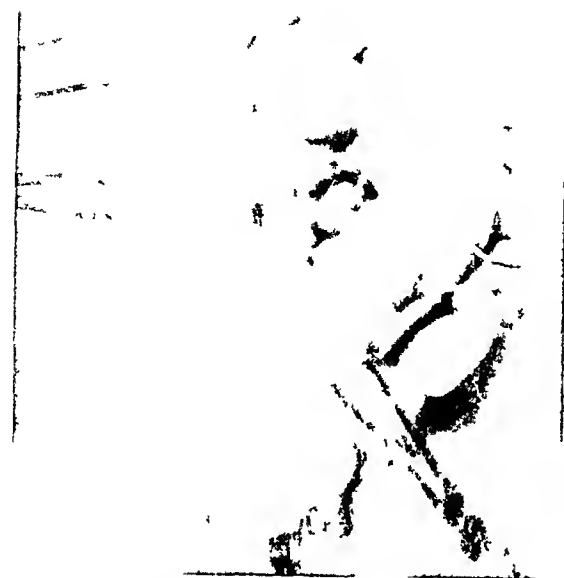


FIG 95—Photograph of benign giant celled tumour of tendon sheath, taken at time of operation

The skin wound healed easily although it was left in a very thin state at the end of the operation.

THE SPECIMEN (Report by Dr R W Scarff, Bland-Sutton Institute of Pathology, Middlesex Hospital)—An irregular encapsulated tumour measuring 4 × 2 cm

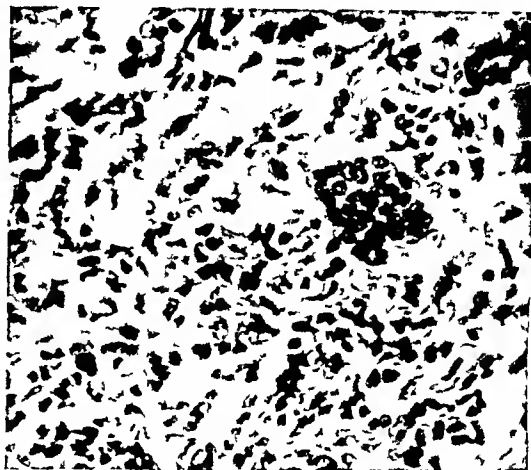


FIG 96—Microphotograph of benign giant celled tumour of tendon sheath ( $\times 300$ )

Section (Fig 96) shows a moderately cellular spindle-cell stroma with areas of fibrosis. Scattered throughout this stroma are numerous multinucleated giant cells and collections of foam cells. Frozen section shows that these foam cells contain fat and doubly refractile lipid. The tumour also shows some attempt at the formation of synovial spaces.

**Diagnosis**—Benign giant-celled tumour of tendon-sheath

We should like to thank Dr R W Scarff for his help in reporting upon the sections and for the microphotograph.

## REVIEWS AND NOTICES OF BOOKS

**Minor Surgery** By R J McNEILL LOVE, M.S. (Lond.), F.R.C.S. (Eng.), F.I.C.S., Surgeon, Royal Northern and Metropolitan Hospitals, etc. Second edition. 7 × 4½ in. Pp 392 + viii, with 201 illustrations. 1944. London: H K Lewis & Co. Ltd. 15s. net.

WHEN does a fad become a fashion? This is at least the third book with the title *Minor Surgery* to be published in four years. The fashion must be spreading, as this is the second edition. The author begins his preface by telling the reader "It is not an easy task to define precisely the limits of minor surgery", so perhaps wisely he doesn't attempt it. He intends it to be a guide and aid to House Surgeons and Practitioners "who from choice or necessity feel called to deal with minor surgical problems or common surgical emergencies". If so, then the principles of surgery should be more stressed and clearly stated in the first part of the book, otherwise the practitioner will not be too happy to class himself with he

"Who doomed to go in company with Pain  
And Fear, and Bloodshed miserable train  
Turns his necessity to glorious gain"

Too much has been attempted in the space allotted, hence the impression remaining in the reader's mind is that no complete picture of any condition is adequately portrayed. The examination of the patient should commence naturally with the history, but not merely of the conditions mentioned in the text, viz, gastric and duodenal ulcers and cholelithiasis, but in many others. The majority of patients present themselves either with a lump or a pain, or both, and the history of mode of onset, accident, previous attacks, etc., might be mentioned to guide the house surgeon.

Physical signs are compressed into thirteen pages, it would be better almost if they were omitted altogether.

Antisepsis and asepsis is next considered, but no definite lead is given from the author's experience which would be so useful to the young practitioner who finds himself compelled to act on his own responsibility. "True necessity hath no law", but as Robinson Crusoe said, "necessity makes an honest man a knave" and this perhaps might be avoided.

In discussing wounds, treatment by sulphonamides is dismissed with "If considered necessary a prophylactic course of chemotherapy is prescribed". How this is done is not stated, and penicillin is omitted altogether.

The importance of covering a superficial wound with skin which is the ideal dressing by immediate or later grafting is not stressed, nor the importance of not interfering with blood-supply by sutures.

The precautions and dangers in the use of the tourniquet should be impressed on the house surgeon, and it is surely wrong to state "They should never be left on for more than two hours without being loosened."

In considering varicose veins, the Trendelenberg test, or any other is not mentioned, and the operation described under his name will not cure the condition nor was it what he described. The risk to the patient of draining a tuberculous abscess is not stressed, but in fact almost encouraged by "The wound is either closed or drained for twenty-four hours if oozing renders drainage advisable."

The remaining part of the book on minor surgical operations, genito-urinary surgery, the eye and ear, bone and joint injuries and anaesthetics will be useful for guidance to any house surgeon. Many of the procedures described will not, however, be presented to the practitioner as a necessity. If accepted as such then he will find that the minor procedure will often become a major responsibility.

him his only real distinction and provide his only valid claim to human status."

The author then proceeds chapter after chapter to consider the anatomy of the foot from the phylogeny and ontology to the arches of the foot, the nerves, and vascular channels.

The whole is redolent of that philosophical anatomical outlook with which the author's name is associated. He even introduced the anatomical outlook to his grandchild many years ago.

"To recognize a Shag a child may learn  
Its little legs are placed so far astern  
And please remember that, despite the name,  
The Cormorant and Shag are just the same."

and he early drew the boy's attention to the foot in telling him of the Kittiwake

"It scorns to live ashore,  
and goes to sea,  
Perhaps to hide its toes,  
For everybody knows  
Instead of having four  
It has but three."

How the man will value this book of *Sea Birds Simplified* with such delightful illustrations by his grandfather.

To proceed with *The Foot*, the difficulties of digital formulae are simplified by the way he enters the lists as the champion of the big toe. Philosophers are wont to applaud the perfections of our enlarged but simple and but recently emancipated mammalian brain, artists pay homage to certain female bodily contours made for the most part of subcutaneous fat, poets wax eloquent over the simplest biological features when they constitute a part of the human body, but the big toe lacks its champion.

How grateful Little Polly Flinders would have been for this book.

It is a book which cannot be adequately reviewed, it must be read, re-read, and digested. Any review would ultimately be like *Hamlet* in the opinion of the old lady who did not like it because it was so full of quotations.

It is a book which will, with that on *The Hand*, take its rank as an anatomical classic, both being a worthy culmination of his earlier collections of *Unscientific Excursions* and *Unscientific Essays*, which, like his *Life and Living*, reflect his devotion to the truly scientific outlook on life both in structure and function.

**Spina Bifida and Cranium Bifidum** Papers reprinted from the *New England Journal of Medicine* with the addition of a Comprehensive Bibliography. From the Department of Surgery of the Children's Hospital, Boston, and Harvard Medical School. By FRANC D INGRAHAM, M D, with the collaboration of HENRY SWAN, M D, HANNIBAL HAMLIN, M D, JOHN J LOWREY, M D, DONALD D MATSON, M D, and H WILLIAM SCOTT, jun, M D. 9 x 6 in. Pp 216 + iv, with numerous illustrations. Cambridge, Mass. Harvard University Press.

This is a series of five papers reprinted from the *New England Journal of Medicine*, they are now collected in one volume with the addition of a comprehensive bibliography which occupies nearly two-thirds of the book. The first three papers give a general survey of 546 cases, the indications for operation and surgical treatment, and an analysis of 65 cases of spina bifida occulta. Whilst the authors make no extravagant claims for surgery in these serious conditions, they emphasize that a hopeless prognosis should not be given hastily. In occult defects in particular they suggest that exploration is indicated more frequently than is generally recognized. The fourth paper describes an unusual case of herniation of the brain through the cribriform plate and its successful

**Structure and Function as seen in the Foot** By FREDERIC WOOD JONES, D Sc, FRS, FRCS, Professor of Anatomy, University of Manchester. 8½ x 5½ in. Pp 329 + iv, with 150 illustrations. 1944 London Baillière, Tindall & Cox. 25s net.

THE author states in the Preface that this book is supplementary to *The Principles of Anatomy as Seen in the Hand*, and stresses the point in the first chapter that it would be an exaggeration to say that it were better for the surgeon who would treat the disabilities of the foot, had he never learned of the structure and function of the hand, but there is a very real element of truth in such an overstatement.

Later, when considering the action of the muscles on and in the foot, he justifies what he is pleased to call this "apparently absurd observation."

The motive of the book is given in the italicized sentence introducing the first chapter "For the most part we have little pride in our feet and it is a pity that it is so", and later "many take a real delight in the appearance of their hands and find æsthetic pleasure in regarding the hands of others." There is no justification for this on anatomical grounds, and "even the human anatomist is rather given to treating the foot as a sort of poor relation of the hand."

It is thus as it should be that the reader's appetite is continually whetted while reading the successive chapters. He realizes that this is no mere dry description of the anatomy of the foot as seen in ordinary text-books. He will find himself continually turning back to a previous chapter in order that he can more clearly understand the subsequent ones.

The ageing surgeon can only put down the book after some hard reading of it with a sigh and wish that anatomy had been taught to him by such a master of the subject. He will also realize after reading the book and re-reading the one on *The Hand*, the close relationship between anatomy and physiology, what one might call functional anatomy and structural physiology, or, as the author would probably prefer, "design and purpose."

The foot of man is taken by the author to illustrate his thesis as "It is all his own. It is unlike any other foot. It is the most distinctly human part of his anatomical make up. He may speak slightly of feet of clay and imagine his form to be divine with perhaps the exception of his feet, but with all his conceit he must not ever forget that it is in fact his feet that confer upon

treatment through a frontal approach. The last paper is a study of 20 cases of the Arnold-Chiari malformation, a herniation of the cerebellum and brain-stem into the cervical part of the spinal canal associated with spina bifida and myelomeningocele.

For those concerned with this branch of surgery the work will prove interesting and stimulating.

**Shoulder Lesions** By H. F. MOSELEY, M.A., D.M., M.Ch. (Oxon), F.R.C.S. (Eng. and C.), F.A.C.S., Lecturer in Surgery, McGill University, Assistant Surgeon, Royal Victoria Hospital, Montreal. 9½ × 6½ in. Pp. 181 + vi, with 70 illustrations. 1945. Springfield, Ill. Charles C. Thomas (London: Baillière, Tindall & Cox). \$4.50.

THE main objective of this book as stated by the author is to carry on where E. A. Codman, of Boston, left off. Codman's well-known monograph on affections of the shoulder-joint was highly individualistic, as might be expected in a pioneer work. Mr. Moseley seems to have followed this lead. He writes with enthusiasm, the subject-matter is attractively presented, but in actual fact the content is largely derived from the writings of others. His personal experience, if one may judge by the material recorded in detail, appears to be somewhat limited. A large amount of space is allotted to two lesions of the shoulder—rupture of the rotator cuff (old style supraspinatus tendon rupture) and calcification in the rotator cuff. In recent years these lesions have figured prominently in American orthopaedic literature. There are also two chapters contributed by colleagues on the neurological aspects of shoulder pain and on X-ray diagnosis and treatment, respectively. These sections contribute to the lack of balance which is a characteristic of the book. They extend beyond the limits of the subject, and have not been critically interwoven into the text as a whole. The X-ray section shows some of the fallacies of radiographic diagnosis *in vacuo* as applied to lesions of the skeleton.

The elegant format of this work will excite the envy of British publishers in these days of paper scarcity.

**Hey Groves' Synopsis of Surgery** Edited by CECIL P. G. WAKELEY, C.B., D.Sc., F.R.C.S., FRSE, F.A.C.S., F.R.A.C.S., Senior Surgeon to King's College Hospital, etc. Twelfth edition. 7½ × 4½ in. Pp. 632 + viii, with 195 illustrations and 13 coloured plates. 1945. Bristol: John Wright & Sons. 25s. net.

"Two hours meditation might furnish him unspeakably to the performance of more than a weekly charge of sermoning not to reckon up the infinit helps of interlinearies, breviores, synopses and other loitering gears" (*Areopagitica*, 1644).

Thus did Milton justify a synopsis in a speech for the liberty of unlicensed printing to the Parliament of England, and when this book is used in the way intended by its original author, the late Ernest Hey Groves, and the present editor of this, the twelfth edition since 1908, the contention is fully justified.

A *Synopsis of Surgery* is quite different, in its inception and execution, from books stigmatized as 'Minor Surgery' or 'Aids to Surgery' which are now only too common. These are comparable to the various 'Digests' one sees on railway bookstalls, and, alas, only too popular. They are filled with snippets of interesting but often inaccurate information, torn from their context, and then used by their votaries as a short cut to a pose of being well read and widely informed. Such information is often used as a cloak for ill education as surely as

"The bookful blockhead ignorantly read  
With loads of learned lumber in his head."

As the late Ernest Hey Groves said in the Preface to the first edition, "The title of this small book describes its aim and scope." He continues, "It has been compiled almost entirely from notes made by the author in preparing students for examinations." Now, whatever one may think of the system of examinations, it does one thing, and that is help both directly and indirectly in making the student and future medical practitioner marshall and present his facts and so conduces to clear thinking and expression which is of the greatest value in his life's work, whether this involves him dealing with patients, committees, or the mystery of nature surnamed Research.

It is from this point of view that Hey Groves's *Synopsis* has been invaluable to many students and surgeons. To many of the latter whose copies have been interleaved, it has become an invaluable book of reference.

The editor of this new edition says "Hey Groves was a friend and surgical father to me." This will be echoed by many, truly the revision must as he says have been "a labour of love."

The format of the book and sequence of the chapters has not been changed, first principles remain first. The first definition of inflammation has been slightly expanded, but by this also loses some of its direct terseness which was so characteristic of the author.

The effects of the crush syndrome, blast injuries, sulphonamides, and penicillin are all recorded. Radium treatment in malignant conditions is stressed throughout and the possibility of endocrine treatment appropriately mentioned. The indications for Trendelenberg's operation for varicose veins are given, they were omitted in the last.

The book is one which every student and practitioner can legitimately possess, not to take the place of the larger text-books, but to be used with them, to amplify and help in the proper method of approach and the reading of them. Its value is like that of a crib to classical authors, composed and annotated by a recognized authority.

It was a happy idea to preface this edition with a portrait of Hey Groves "in the cheery mood which was such a stimulus and example to us all", and it enhances its value immensely to those who knew him. The adopted son of his surgical father has fulfilled his task with the filial care one would expect of him, not only as the editor of the *Synopsis*, produced in 1908, but also as editor of the later child by the same father which was born in 1913—*The British Journal of Surgery*.

**Clinical and Roentgenological Studies of Acute Obstruction of the Small Intestines due to Adhesions and Bands** From the Surgical Clinic in Lund and from the Roentgendiagnostic Department in Lund. Being Supp. 88 (in English), vol. xc, of *Acta Chirurgica Scandinavica*. By FREDRIK KOCH. 9½ × 6 in. Pp. 165. Stockholm. Kr. 25.

THIS monograph deals with a collection of 145 cases of acute intestinal obstruction due to adhesions and bands. The majority of the cases had been submitted to a previous abdominal operation. The interval between the operation and the onset of the ileus varied between a month and thirty years. The commonest cause of adhesions proved to be gynaecological operations. Laparotomies in the upper abdomen very seldom cause an adhesion ileus.

In Sweden X-ray examination (plain photographs) is a part of the routine investigation of each case of suspected ileus. Distended small intestinal loops with fluid levels are diagnostic of ileus.

This book is illustrated with good radiographs, which prove the value of this form of investigation in these cases. The clinical data are well documented and the references are comprehensive.

**Cleft Palate and Speech** By MURIEL E MORLEY, B Sc, F C S T, Speech Therapist to the Royal Victoria Infirmary, The Hospital for Sick Children, and The Newcastle General Hospital, Newcastle-upon-Tyne  
7½ x 4½ in Pp 160 + vii, with 52 illustrations  
1945 Edinburgh E & S Livingstone Ltd  
7s 6d net

THE importance of this monograph can be appreciated when it is known that cleft palate and lip tend to occur approximately once in every 1000 births. It is therefore a common congenital deformity. In the past a very satisfactory operation on the palate often resulted in a poor speech result, the patient still speaking with a marked nasal utterance. The modern methods of treatment of cleft palate demand the co-operation of the surgeon, dental surgeon, and speech therapist. Miss Morley has written a concise, readable, and practical book on speech therapy, and she helps us to understand and analyse our speech results. It is to be hoped that all surgeons who operate on cleft-palate cases will read this book to their great advantage.

**The 1944 Year Book of Industrial and Orthopedic Surgery** Edited by CHARLES F PAINTER, M D, Orthopedic Surgeon to the Massachusetts Women's Hospital and Beth Israel Hospital, Boston  
7 x 4½ in Pp 432, with 282 illustrations  
1945 Chicago The Year Book Publishers Inc (London H K Lewis & Co Ltd) 18s net

THESE Year Book publications are of value because they give the reader a synopsis of the latest methods of treatment in the different subjects. The year book devoted to industrial and orthopedic surgery contains a wealth of material owing to the great stimulus that the world war has given to these branches of surgery.

Industrial surgery has come into its own, and the medical profession is beginning to see the necessity for this new branch of surgery. Finger injuries, the bane of industry, must be treated promptly, otherwise the amount of time lost will be very considerable. The value of radiographs on the spot in every factory has at last been recognized. The importance of salt in preventing illness from exposure to heat has at last become generally known. It has also been suggested that vitamin C is valuable in the prevention of heat disease.

The role of chemotherapy in traumatic surgery is well set out in this book, especially in the treatment of compound fractures. There are many reasons why chemotherapeutic agents should be highly regarded by surgeons, and some previous notions about surgical principles will have to be revised on account of them, but exercise, good judgement, and common sense are still required.

Every surgeon who is interested in traumatic surgery should read this book, it will make a special appeal to Medical Officers in the fighting Services.

**Surgery** A Textbook for Students By CHARLES AUBREY PANNETT, B Sc, M D, F R C S, Professor of Surgery, University of London, Director of the Surgical Unit, St Mary's Hospital, London  
9½ x 6½ in Pp 740 + xii, with numerous illustrations  
1944 London Hodder & Stoughton Ltd 35s net

THERE are many text-books on Surgery, but very few which have been written solely by a single surgeon without the help of a colleague. Professor Pannett has, however, written such a book and illustrated it himself. All the special surgical subjects, including the surgery of the eye, nose, throat, and the female genital organs have been purposely omitted. The author, therefore, has been able to concentrate on general surgery as a whole without any detail on the fundamentals of pathology and

bacteriology. It may well be that in the future other well-known text-books on surgery will conform to this arrangement that Professor Pannett has introduced, time alone will answer this problem.

The book has been written from the extensive experience of a well-known general surgeon, and his experience as an examiner in many universities has made him *au fait* with the difficulties of the medical student in the final surgical examination. Hence it comes about that the book is written in an easy but didactic style. The student who reads this book should be able to pass in surgery in any final pass examination, but there is not sufficient material for any of the higher surgical examinations. The illustrations are good on the whole, but some of them appear to have a decided Victorian style about them. This book will take its place amongst the numerous text-books on surgery.

**Hypertension** A Manual for Patients with High Blood-pressure By IRVING H PAGE, A B, M D, Director, Lilly Clinic, Indianapolis City Hospital  
7½ x 5 in Pp 80 + xi, with 7 illustrations  
1944 Springfield, Ill Charles C Thomas (London Bailliere, Tindall & Cox) \$1 50

How much knowledge should a patient have about his own disease? The answer will depend upon his intelligence and the nature of the disease. This is a book written in simple language for the patient, describing the essential features of hypertension and giving guidance to the sufferer on his mode of life. There is no doubt that books on a disease such as diabetes have been of great value, possibly hypertension comes into a similar category and those who are of that opinion will recommend this book to their patients.

**Surgical Errors and Safeguards** By MAX THOREK, M D, LL D, Professor of Surgery, Cook County Graduate School of Medicine, etc. With a Foreword by Sir HUGH DEVINE and a Chapter on Legal Responsibility in Surgical Practice by HUBERT WINSTON SMITH, A B, M B A, LL B, M D. Fourth edition, completely revised 10 x 6½ in Pp 1085 + xvii, with 794 illustrations, many in colour  
1945 Philadelphia and London J B Lippincott Co 90s net

THIS is the fourth edition of a book which is already too well known to need an introduction. New features are chapters on Plastic Operations and on Electro-surgical operations, but much of the work has been reviewed and rewritten since the last edition appeared. A particularly valuable addition is a section of several chapters by Dr Hubert Smith, of Harvard University, on the medico-legal aspects of surgical practice, which, though written primarily for practitioners in the United States, contain information and advice which is equally valuable in Great Britain.

We learn from our mistakes, but it is better for our patients if we can learn a good deal from the mistakes of others. We have to find out where danger lies and plan our operations, so as to avoid the errors and the dangers of surgery. It is to be noted that the author now heads most of his chapters "Dangers and Safeguards"—a preferable title to "Errors and Safeguards".

The chief safeguards are good surgical technique, asepsis, the control of haemorrhage, the choice of the anaesthetic, a thorough general examination of the patient, and a knowledge of the anatomy of the important structures which may be encountered in the course of an operation and which must be protected and spared. All these are given proper consideration in the early chapters of the book, and the special features of operations on the various organs and parts of the body are considered on a regional basis.



It is our experience—that is, some would say, our mistakes—which teaches us, and nobody nowadays can have extensive experience of all branches of surgery, for the field is too vast, and it is essential to concentrate on a few special subjects if good work is to be done. Thus the weight of experience is bound to vary, and this inequality is detectable in the present work, though the author has taken the trouble to draw upon the experience of others, with numerous quotations from, and references to, their work when he feels that his own is deficient. In spite of this borrowing from other surgeons the book remains very much an expression of the ideas and the practice of one man, who has placed before us a panorama of his surgical life and thus offers to his readers a book which is full of interest, provides useful information, and provokes serious thought.

**Fraetures and Orthopædic Surgery for Nurses and Masseuses** By ARTHUR NAYLOR, Ch M, M B, M Sc, F R C S (Eng and Edin), Resident Surgical Officer, Westwood E M S Hospital, Bradford, Examiner in Surgery, General Nursing Council, etc. With a Foreword by Professor ERNEST FINCH  $8\frac{1}{2} \times 5\frac{1}{2}$  in Pp 288 + xii, with 243 illustrations 1945 Edinburgh E & S Livingstone Ltd 16s net

THIS is a new book which is lavishly illustrated with photographs and drawings. These are excellent and well chosen and will materially assist the reader, who may find parts of the text difficult to understand. Few medical students read a book of this specialized type and would benefit as much as will those nurses and masseuses who wish to acquire a knowledge of this branch of surgery so that they can carry out the after-care and treatment of the injured and deformed which is delegated to them.

Definitions and brief descriptions of many lesions are clear and concise. Symptoms, signs, and up-to-date methods of treatment are suitably described. The nurse will find useful the descriptions of immediate requirements after the application of a plaster splint and of other apparatus. There is no attempt to describe general nursing principles or to teach physiotherapy, for the book is intended for nurses and masseuses to learn the surgical aspect of the conditions they may be called upon to treat at the direction of the surgeon. The author has succeeded in providing what is required for the teams who now work as 'menders of the maimed'.

This book will find its place not only in the libraries of Nurses' Homes and Physiotherapy Training Schools, but also as a valuable reference book for many interested in the subject.

## BOOK NOTICES

*[The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest for our readers.]*

**Symposium on Recent Advances in Surgery** Reprinted by the United States Office of War Information from the *Surgical Clinics of North America* (Philadelphia Number) for December, 1944, with the permission of its publishers the W B Saunders Company, Philadelphia and London  $9 \times 6$  in Pp 1281-1507, with 75 illustrations

**The Art of Anæsthesia** By PALUEL J FLAGG, M D, New York. Seventh edition  $9 \times 6$  in Pp 519 + xxx, with 163 illustrations 1945 Philadelphia and London J B Lippincott Co 36s net

**Acute Injuries of the Head** Their Diagnosis, Treatment, Complications and Sequels By G F ROWBOTHAM, B Sc (Manch), F R C S (Eng), Surgeon in Charge, Department of Neurological Surgery, Newcastle General Hospital, etc. With a Foreword by NORMAN M DOTT. Second edition  $9\frac{1}{2} \times 6\frac{1}{2}$  in Pp 424 + xvi, with 201 illustrations, 12 in full colour 1945 Edinburgh E & S Livingstone Ltd 30s net

**A Text-book of Surgical Pathology** By CHARLES F W ILLINGWORTH, M D, Ch M, F R C S (Ed), Regius Professor of Surgery, University of Glasgow, and BRUCE M DICK, M B, F R C S (Ed), Surgeon for Diseases of the Chest, E M S, West of Scotland. Fifth edition  $9\frac{1}{2} \times 6$  in Pp 728 + viii, with 306 illustrations 1945 London J & A Churchill Ltd 42s

**The Treatment of Acute Intestinal Obstruction** By JUDSON T CHESTERMAN, M R C P (Lond), F R C S (Eng), F A C S, Surgeon, City General Hospital, Sheffield, Hon Lecturer, Surgical Pathology, Sheffield University  $8\frac{1}{2} \times 5\frac{1}{2}$  in Pp 116 + viii, with 13 illustrations 1945 London J & A Churchill Ltd 10s 6d net

**Achievement in the Art of Healing** By JOHN LANGDON-DAVIES  $12\frac{1}{2} \times 9\frac{1}{2}$  in Pp 36 Illustrated 1945 London Pilot Press Ltd 2s 6d

**Surgical Disorders of the Chest** Diagnosis and Treatment By J K DONALDSON, B S, M D, F A C S, Major, M C, A V S, Associate Professor of Surgery and in Charge of Thoracic Surgery, University of Arkansas School of Medicine, etc  $9 \times 5\frac{1}{2}$  in Pp 364, with 127 illustrations 1945 London Henry Kimpton 33s net

**An Index of Differential Diagnosis of Main Symptoms** By various writers Edited by HERBERT FRENCH, C V O, C B E, M A, M D Oxon, F R C P, Consulting Physician, Guy's Hospital, late Physician, H M Household, assisted by ARTHUR H DOUTHWAITE, M D, F R C P, Physician, Guy's Hospital, Honorary Physician, All Saints' Hospital for Genito-urinary Diseases. Sixth edition  $9\frac{1}{2} \times 6\frac{1}{2}$  in Pp 1128 + viii, with 798 illustrations, of which 231 are coloured 1945 Bristol John Wright & Sons Ltd 84s



# THE BRITISH JOURNAL OF SURGERY

VOL XXXIII

OCTOBER, 1945

No 130

## PHARYNGEAL DIVERTICULA\*

By JOHN MORLEY

PROFESSOR OF SURGERY, MANCHESTER UNIVERSITY

PHARYNGEAL diverticula are among the less common causes of dysphagia, but they may give rise to great disability, and while the diagnosis of the condition is usually simple there is considerable controversy as to the best method of treatment

The remarks that follow are based on a series of 21 uncomplicated pouches operated on by me, and 2 cases complicated by the development of epithelioma in the pouch

### SURGICAL ANATOMY

These pouches were described by Zenker as "pulsion diverticula" produced by pressure from within the pharynx, as opposed to the relatively unimportant traction diverticula that occur lower in the œsophagus. Their site is a constant one, and is determined by an anatomical weak spot in the posterior wall of the pharynx at its lower end between the transverse and oblique fibres of the cricopharyngeus. The pouch arises as a herniation of mucous membrane through this potential gap and, once started, its gradual increase in size will follow inevitably as a result of the repeated force of deglutition. E. D. Gray (1932) has described the earliest stage of this herniation that is radiologically demonstrable. In a series of 250 consecutive X-ray examinations of the pharynx he saw in 6 patients a pointed barium-filled projection from the posterior pharyngeal wall at the level of the cricoid which is regarded as a potential pharyngeal diverticulum. The initiation of the process of herniation, however, is not easy to explain. Cases have been reported in which some organic obstruction to the œsophagus lower down, such as a fibrous stricture or an intrathoracic thyroid adenoma, has provided a ready explanation of the increase in intrapharyngeal pressure that must surely be the essential factor in causation. But these cases are exceptional, and there were none such in my series. One must assume some spasmodic obstruction on the part of the circular fibres in the upper œsophagus, which raises the intrapharyngeal pressure sufficiently to start the bulge, but there is no solid basis of fact behind this assumption, and it is noteworthy that in the common condition of cardiospasm or achalasia of the cardiac 'sphincter' of the œsophagus, these diverticula do not occur

I must digress briefly at this point. In 1926 when I reported three diverticula (included in the present series) in the *British Medical Journal* (1926) the late Sir Arthur Hurst wrote to me to point out that one of the illustrations of my article (*Fig 97, A*)



FIG 97—A, Lateral view of pharyngeal pouch showing barium lodged in the vallecule. B, Anteroposterior view of the same pouch with both vallecule filled with barium

showed, in addition to the pouch that I had removed, an anterior pharyngo-œsophageal pouch such as he had described shortly before in the *Guy's Hospital Reports* (1925). He enclosed a reprint of his article which was entitled "Anterior Pharyngo-œsophageal Pouch as a Cause of Dysphagia". The article described one case only, but in his letter Hurst said "Since the publication of my paper I have seen another similar diverticulum which caused no appreciable dysphagia in a patient with duodenal ulcer."

Now it was obvious from the radiographs in Hurst's article that the shadow of his 'pouch' was situated a good 2 in. above the lower end of the pharynx, and in consultation with the late Dr. E. W. Twining I came to the conclusion that his illustrations showed nothing more than barium lodging

\* A paper read before the Manchester Medical Society on April 4, 1945  
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in the valleculæ between the back of the tongue and the front of the epiglottis. I wrote to Sir Arthur Hurst to this effect, and the following October I received this reply: "I have waited all this time before writing to you again, as I wished to have an opportunity of re-examining the patient with the supposed anterior œsophageal diverticulum. I have now done so, and must candidly confess that I am quite convinced by your arguments. What we took to be a diverticulum was an unusually developed vallecula in front of the epiglottis. It can have had nothing to do with the dysphagia, which is still present in our patient, though no worse than 18 months ago. I am very grateful to you for your long letter, and I shall take the earliest opportunity of correcting my former statements on this subject in the *Guy's Reports*."

Unfortunately the many claims on Sir Arthur Hurst's time and energies never permitted him to publish his promised correction, and last year, after a long struggle against failing health, he passed away.



FIG 98.—A large pharyngeal pouch containing food which was regarded as an intrathoracic goitre.



FIG 99.—The same pouch filled with barium.

I have, therefore, thought it right to publish this correspondence, and in doing so I should like to acknowledge the great courtesy and the candour with which he admitted his error.

### PREDISPOSING CAUSES

**1 Age**—Pharyngeal pouches occur as a rule in late middle age. In my series the average age at operation was 60, the oldest patient being 76 and the youngest 36. The patients' statements as to the age of onset of symptoms were too vague for precise calculations, but in most cases symptoms had been present for from 5 to 10 years before operation.

**2 Sex**—The condition is commoner in men than in women. In my series of 21 patients with uncomplicated pouches there were 14 men and 7 women. The 2 patients who had pouches complicated by epithelioma were both men. Lotheissen

(1931) states that 79 per cent of the patients are males. No other predisposing factor such as heredity or occupation emerges from a study of my series, nor is there any evidence that the chronic cough of bronchitis is an important factor.

### SYMPTOMS

Some degree of dysphagia, associated with regurgitation of food, is the most constant symptom, but patients and their friends complain with almost equal frequency of a most disagreeable gurgling noise on swallowing food or even saliva. At times there are attacks of violent coughing and choking when food is regurgitated and begins to enter the glottis. Finally, there is loss of weight. In the early stages the weight may be well maintained, and the symptoms are more an annoyance or inconvenience than a source of ill health. Patients complain that much time is consumed in getting their meals down. Gradually as the pouch enlarges the obstruction to the passage of food into the œsophagus

becomes more pronounced, and in a later or neglected case there is progressive emaciation. In some cases a large pouch, when full of food, presents a visible and palpable swelling in the neck, usually to the left side, with both gurgling and regurgitation of food on pressure.

### DIFFERENTIAL DIAGNOSIS

Carcinoma of the œsophagus, besides being a much more common cause of dysphagia than pharyngeal pouch, has a similar age and sex incidence. Patients with pharyngeal pouch usually give a much longer history, and though in the later stages they may show progressive emaciation, there is no such pallor from secondary anæmia as accompanies the emaciation caused by œsophageal carcinoma.

Broadly speaking, the differentiation from other causes of dysphagia such as carcinoma, cardiospasm,

and cicatricial stenosis, depends upon X-ray examination with a barium swallow. But occasionally in a straight radiograph of the chest, when a pouch of considerable size is full of food, the shadow in the superior mediastinum may be interpreted as an intrathoracic goitre, as happened in the following case —

A man aged 51 was referred to me from the medical wards of the Infirmary as a case of intrathoracic goitre with a history of a 12-months' loss of weight, shortness of breath, and difficulty in swallowing. Radiography of the chest (Fig 98) was reported as "very much in favour of retrosternal goitre. The gland is evidently enlarged more to the right." The basal metabolic rate was increased by 41 per cent. The pulse, however, was only 72, there was no lid retraction and no tremor of the hands or perspiration, and he had no dilated veins over the upper sternum and neck. The diagnosis of pharyngeal pouch was suggested by a characteristic gurgling noise when he swallowed saliva, and a barium swallow confirmed the presence of a large pouch (Fig 99).

### ASSOCIATION OF PHARYNGEAL POUCH WITH CARCINOMA

In addition to the series of 21 patients with uncomplicated pouches I have had 2 patients with squamous epithelioma developing in an old-standing pouch. A similar case has been recorded by Capps and Dunhill (1933), and Fitzwilliam (1934) described a case of epithelioma arising in a pouch five years after an operation in which the pouch was suspended upwards in the neck by suture without removal.

My first case was a man aged 57 who had had dysphagia for 16 years, and in whom a radiograph 10 years earlier had shown a pouch. Two months before I saw him his dysphagia had become much more urgent, and he had lost weight rapidly since then. Obstruction was now practically complete. A radiograph now showed a filling defect at the neck of the sac, which prevented the barium from entering either the sac or the oesophagus. A gastrostomy was performed, and the presence of a fixed and inoperable epithelioma originating at the neck of the pouch was established. The patient survived the operation 5 months.

The second patient was a man of 78. Forty years before, in the days before X rays, the late Sir Felix Semon had diagnosed a pouch. It had not troubled him greatly until the last few months, when the dysphagia became rapidly worse. He had lost weight quickly and on several occasions had brought up a little blood mixed with frothy expectoration. He complained of recent pain in the left side of the neck. Radiography showed a fairly large pouch with a filling defect at the neck of the sac.

As he was unable to swallow even fluids except with great difficulty, operation was undertaken. Under intratracheal gas and oxygen the pouch was first exposed in the neck, which was adherent both to the spine and the trachea. Excision was plainly impossible. A Witzel gastrostomy was performed. The patient developed hypostatic pneumonia and died in 24 hours. A specimen of the growth was removed post mortem and was a squamous epithelioma.

While we do not know the precise liability to the development of malignant growths in these pouches, their occurrence in a small proportion of old-standing diverticula provides argument for excision of the sac before such a lethal complication can arise.

### TREATMENT

In patients with small pouches whose symptoms are only a mild annoyance rather than a serious threat to their life, any question of surgical treatment may well be postponed, and especially if the patient by reason of age or infirmity is a poor operative risk.

Where treatment becomes imperative we have the choice between excision of the pouch and some minor measure designed to secure relief of symptoms without the dangers associated with excision. Of these minor procedures, invagination of the sac into the pharynx would plainly be feasible only for the very small pouches, and even so would be likely, one would think, to cause mechanical embarrassment both to deglutition and breathing. The operation of diverticulopexy, in which the pouch is suspended in an upward direction by suturing it to the hyoid bone or the side wall of the pharynx is said to give complete relief in some cases, but recurrence of symptoms is far too common. It is plain that complete excision of the pouch is the only satisfactory method.

The obvious method of primary excision and suture in one stage fell into some disrepute in the early years of this century on account of the high incidence of leakage, with sepsis and suppurative mediastinitis in some cases leading to a fatal result. It was in order to obviate this risk that Goldmann (1908) introduced the operation of excision in two stages. In the first stage the sac was isolated, ligated, and brought out through the skin incision to the left side of the neck. Ten days later the necrotic sac was extirpated by the thermocautery. Wilkie and Hartley (1922) advocated the Goldmann two-stage operation with a slight modification, but admitted that a fistula could be expected in about 50 per cent of cases.

Lahey (1937), in a paper based on an operative experience of 82 cases and a follow-up study of 53, states that he sticks to the two-stage operation because "we have had such a low mortality with it and because it gives us such a feeling of comfort and security to realize that with it the dangers of deep cervical cellulitis and mediastinitis are eliminated." He had, however, 18 cases that developed a fistula after the second stage and 5 with secondary abscesses. Two patients had a complete recurrence due to inadequate removal of the sac, and 2 others a partial recurrence with some symptoms. One died of uræmia after the first stage and 1 feeble patient had the first stage only performed.

Harrington, discussing Lahey's paper, states that of 227 cases operated on at the Mayo Clinic 47 were done by one-stage and 180 by two-stage technique. Shallow, in the same discussion, described 99 cases operated on by one-stage excision with 4 deaths, none of which were from mediastinitis.

V Schmieden (1930) advocated the one-stage operation. In 7 cases 3 healed by first intention and 4 developed fistulae which were of short duration.

My own 21 cases have all been treated by primary excision of the pouch and suture of its neck. There have been no deaths.

I regard the two-stage operation as unnecessary and tedious for both patient and surgeon. Primary resection is, however, a difficult operation and should in my view only be undertaken by those who have

adequate experience of gastric and intestinal resection. The sac should be washed out frequently with mild antiseptics for a few days before the

The pouch is exposed by a transverse collar incision at the level of the cricoid cartilage, as for a thyroidectomy, rather than by the more usual but unsightly

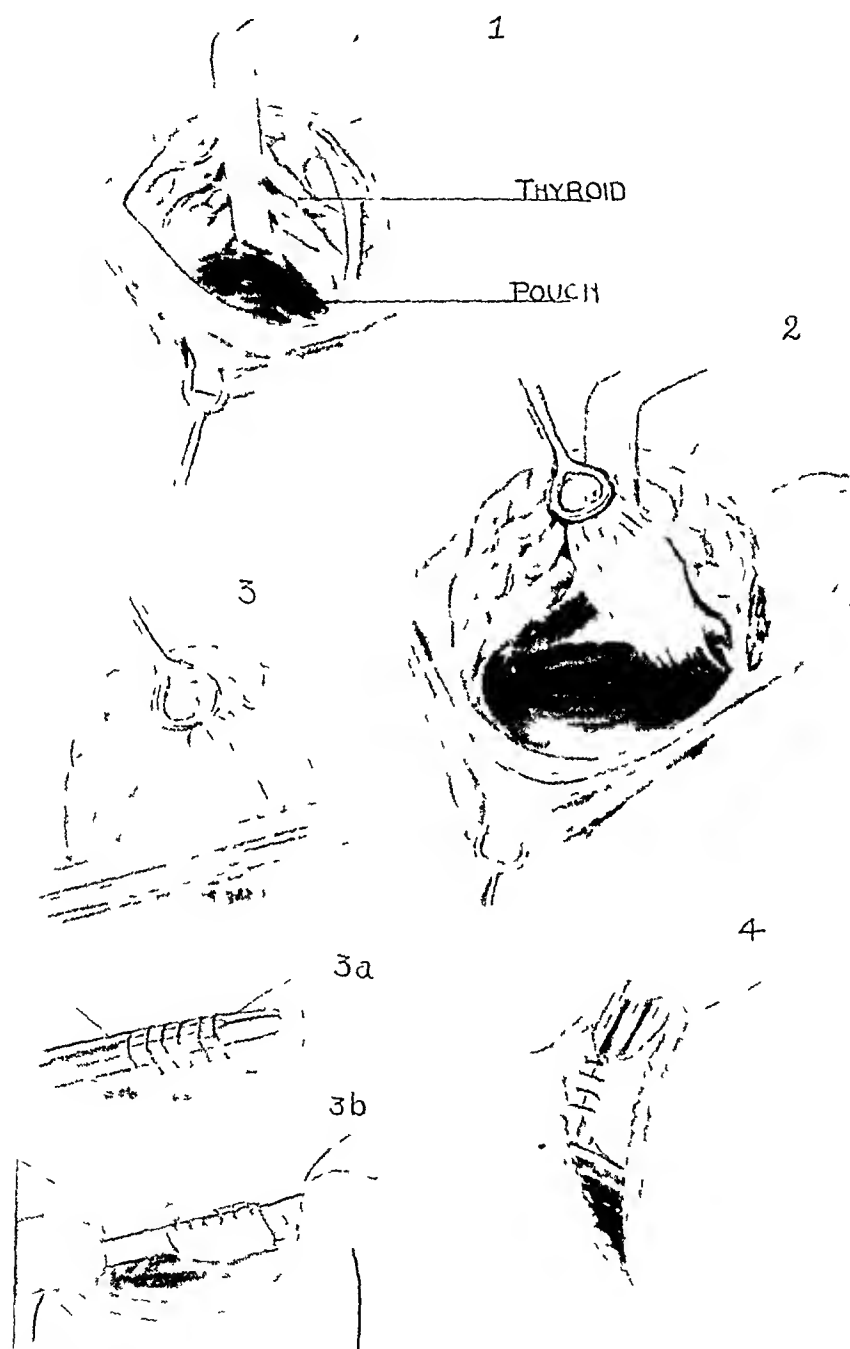


FIG 100—Showing the stages of the operation. (1) Exposure of the pouch. (2) The pouch dissected free. (3) Clamps applied near base of pouch, (3a) Continuous inverting suture applied over clamp, (3b) The suture pulled tight after removal of the clamp, (4) Closure of the wound with insertion of a rubber dam drain.

operation and should receive a final wash-out and be emptied by a catheter just before the operation. I regard endotracheal gas and oxygen or cyclopropane as the anæsthetic of choice, though the operation can be done under local anæsthesia alone.

incision along the anterior border of the left sterno-mastoid. It is approached more readily on the left side, unless, as sometimes happens, the radiograph shows that the pouch inclines more to the right. The infrahyoid muscles are usually divided

transversely on the left side, and the thyroid gland is thus exposed. The left middle thyroid vein is ligated and divided and by retracting the carotid sheath laterally and the thyroid gland and trachea medially the pouch is identified (*Fig 100, 1*). It is delivered and dissected clear up to its junction with the pharynx (*Fig 100, 2*). This dissection is facilitated by traction on the fundus of the pouch with a pair of pile forceps. When the sac is quite free and has been drawn upwards and to the left, the anesthetist should pass a full-sized œsophageal bougie past the neck of the pouch into the œsophagus. This requires some help from the surgeon in manipulating the tip of the bougie downwards, and the greatest care must be taken lest the bougie should perforate the thin wall of the pouch. It is not absolutely essential, but it is a safeguard against a too drastic excision of the sac which might lead, after suture, to stenosis of the pharynx. Two pairs of Schoemaker colectomy clamps are then applied side by side near, but not too near, to the neck of the pouch (*Fig 100, 3*). The pouch is now removed by cutting between the clamps with the knife or the diathermy needle, the line of section between the blades of the remaining clamp being then painted with a little pure carbolic acid. A continuous inverting suture of 2/0 chromic gut is then inserted on a small curved needle over the clamp (*Fig 100, 3a*). The clamp is slid off and the suture at once pulled tight, inverting the edges of the sac (*Fig 100, 3b*). The same suture is then brought back along the whole length as a secondary invaginating stitch, and tied to the original end. A few further points of interrupted catgut suture are super-added for greater security and the wound closed, leaving a rubber dam drain down to the suture line for 3 or 4 days (*Fig 100, 4*). An intravenous drip of glucose-saline is advisable for the first 24 hours, with nothing but mouth-washes, but after that the patient may drink sterilized fluids. No solid food is allowed for 8 to 10 days. In all but the largest pouches occurring in debilitated patients, the above technique will prove satisfactory. But where the pouch is a large one and the patient's general condition poor, a preliminary gastrostomy of the Witzel type affords certain advantages. Done 2 or 3 weeks before the pouch is excised, it enables an emaciated patient to put on weight and to stand the excision better. I performed this preliminary gastrostomy on 2 of my patients. In one resection was carried out 2 weeks later. In the other, a septic parotitis followed the gastrostomy and the resection was postponed for 3 weeks. Primary healing followed the resection of the pouch in both cases. In 2 other patients with very large pouches, gastrostomy was performed at the same time as the resection of the pouch. In one of these the pouch, which held  $1\frac{1}{2}$  pints of fluid, was so adherent to the arch of the aorta that it tore during delivery from the superior mediastinum. Both of these cases healed by first intention. The gastrostomy tube was removed in all cases as soon as normal swallowing of solid food had been resumed, and the stoma closed spontaneously at once. Two further patients with large pouches developed severe fistulæ 3 or 4 days after resection, and gastrostomy was performed after the fistula formation in order to keep up their nutrition and to help the fistulæ to heal.

**Results of Resection**—Of my 21 cases, 16 healed by first intention, 3 developed severe fistulæ that took 9 or 10 weeks to heal, one a slight fistula that healed in 2 days, and 2 developed a slight abscess in the neck without fistula formation that healed in a few days.

It is significant that all the fistulæ and abscesses occurred during the last 5 years, in the period of the war. I attribute this to two factors: (1) The poor quality of the clamps used, owing to the impossibility of replacing them by new ones when the blades were strained, so that they tended to slip off the neck of the pouch, and (2) The inferior quality of the war-time catgut. These mishaps serve to point the moral that unless the suture of the neck is impeccably performed a fistula is likely. Even in these unfortunate cases there was no instance of a dangerous septic mediastinitis.

**End-results**—The clinical results have been good in all cases. The patients have regained their weight, and have been uniformly relieved of the unpleasant gurgling in the throat on swallowing. This relief has been no less pronounced in the 3 patients who developed severe fistulæ after operation.



FIG 101—Radiograph showing the large pharyngeal pouch

Radiological examination some time after the operation often shows a small residual pouch, but these do not cause symptoms and do not appear to enlarge progressively.

One strange effect of a resection is worth recording. A male patient, aged 61, with a 17-years' history of dysphagia, who had the largest pouch of the series (*Fig 101*), holding  $1\frac{1}{2}$  pints, had been in the habit of drinking large quantities of neat whisky. The whisky would lie harmlessly in his pouch until such time as he found it convenient to retire and eject its contents, which he did after much practice with great facility. This had gone on for some years, but I was not informed as to his convivial habits at the time of operation, and so could not warn him of the change in his physiology as regards the absorption of alcohol. Within a month of

resuming his accustomed round he developed severe *delirium tremens* and this has been repeated on several occasions since

as compared with resection in two stages are set forth

### SUMMARY

1 A series is described of 21 pharyngeal diverticula treated by one-stage resection and suture

2 Two cases of pharyngeal diverticula complicated by squamous epithelioma originating in the pouch are recorded

3 Hurst's anterior pharyngo-oesophageal pouch is explained by barium in the vallecula between the tongue and the epiglottis

4 The technique and results of the one-stage excision operation are described, and its advantages

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## ACRYLIC RESIN FOR THE CLOSURE OF SKULL DEFECTS PRELIMINARY REPORT

By MAJOR J M SMALL, R A M C, AND MAJOR M P GRAHAM, A D CORPS

FROM A MILITARY HOSPITAL FOR HEAD INJURIES

THE problems of repairing skull defects by artificial replacement of the lost bone are by no means new, but are now of particular importance because of the increasing number of patients with traumatic defects requiring surgical intervention. The materials employed for this purpose have been numerous, and have included silver, celluloid, and, more recently, vitallium and tantalum.

Results in the past have not always been satisfactory, and the use of such foreign bodies has been condemned by many surgeons. We consider that the cause of failure has been mainly due to lack of a suitable material. However, with the development of plastics, particularly acrylic resin, the problem has been largely overcome. This communication describes the use of this material in the prosthesis of cranial defects, and a series of 25 cases is recorded in which this method was adopted. Certain general considerations of skull defect closure are also discussed.

These 25 cases were selected from among 213 requiring closure of skull defects which were operated on at a military hospital for head injuries. The methods used were as follows—

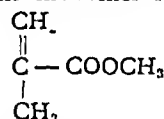
<i>A Autogenous Bone grafts—</i>	
Rib	50
Ileum	6
Tibia	1
Outer table of skull	1
<i>B Plastic and Metal Plates—</i>	
Acrylic resin	25
Tantalum	130

### ACRYLIC RESIN

Chemically, acrylic resin is methyl methacrylate and is derived from acrylic acid. The acid was discovered in 1843, but methyl methacrylate was not produced commercially until 1927. It is now used extensively for windshields and astradomes of aeroplanes, and, since the shortage of rubber, for denture bases.

The acrylic resin used in this series was Kallodent (Clear), I C I Ltd. It is supplied as a monomer

(a clear liquid) and a polymer (a powder, in appearance like castor sugar), and on mixing the two a soft, snow-like mass is produced. Curing takes place under pressure after packing into a mould, and consists of polymerization by heat. The action is irreversible, and the resulting product is a stable, transparent, colourless, and resinous substance. The formula for the monomer is—



**Properties**—The properties required of the ideal material for 'grafting' will be considered first. The material should be one which will lie indefinitely embedded in the tissues, producing no adverse changes in its surroundings, and will itself remain permanently unaltered—that is, a non-irritating, inert substance. In addition, it must fulfil the requirements of strength, simplicity of technique in processing, and ease and accuracy of manipulation.

These properties are possessed by acrylic resin. That it is well tolerated by the body tissues is shown in the paper on its behaviour when implanted into rabbits' skulls (Beck, Russell, Small, and Graham, 1945). The completely polymerized material is chemically inert, the presence of free monomer and its effect need not be considered if the correct heat treatment has been carried out. It is highly resistant to bacterial growth on its surface, and the interior will remain sterile after many months of external contamination (Drury, Caress, and Corin, 1935). From a physical point of view the important factors are that it is light in weight, having a specific gravity of 1.19, and easily manipulated. The production of the 'graft' is by an adaptation of the methods used in denture construction, so that an exact restoration of lost bone can be achieved with certainty and with the optimum cosmetic result. The perfect fitting thus obtained results in immobility, which is of fundamental importance for the

maintenance of any free graft, in addition, point pressure, with possible resultant bony absorption, is avoided. The strength and resistance to deformity of acrylic resin plates are high, and for this reason it is an admirable material for the restoration of the protecting covering for the brain. Other properties which make acrylic resin particularly suitable for the closure of skull defects are its radiolucency and the fact that it is a bad conductor of heat and electricity.

### THE NEED FOR CLOSURE

In considering the repair of skull defects the first question is whether or not it is a necessary procedure. The main indication is usually the desire of the patient to have a solid covering for his brain and so rid himself of the feeling of insecurity so commonly associated with a large skull defect. Intimately connected with this sense of insecurity is the desire for improvement of his personal appearance. It is the patient with the large frontal defect who demands some reconstruction to alleviate these worries, and to prevent a frank anxiety state from developing is of paramount importance in his treatment.

Headaches as an indication for closure must be carefully considered. There are two types of headache commonly relieved by closure of skull defects. The first is local pain at the site of the defect, usually brought on by exertion, this is commonly seen in defects of the temporal or parietal region, possibly due to meningeal vessel distortion caused by pulsation and dural movement. The second is pain referred to the orbits, seen usually in defects in the region of the sagittal sinus, again produced by exertion or change of posture, and almost certainly due to distortion of the sinus and resultant referred pain in the first division of the 5th cranial nerve.

Generalized headache of vague character, described by the patient in a variety of expressive ways, is rarely influenced by skull defect repair. These patients often have other symptoms of the post-traumatic anxiety state, and rarely present themselves with local complaints referable to the skull defect or desire its closure for security or cosmetic reasons; they are more concerned with themselves, and constitute poor subjects for surgical treatment.

There is also a group of patients with skull defects resulting from bone removal at operation in whom closure of the resulting defect can be undertaken at the same operation. This important group is considered under "Operative Defects."

### METHOD OF PERFORMING ACRYLIC 'GRAFTING'

The method here described attempts to replace the missing cranial bone by an acrylic plate which exactly fits the defect and faithfully reproduces the original contour of the skull, thereby giving a perfect cosmetic result.

**Pre-operative Considerations**—Apart from general neurological or general surgical aspects of each case, there are certain specific pre-operative considerations. First of all, the condition of the scalp which will overlie the 'graft' or plate is of paramount importance. Whatever length of time has elapsed since the primary operation, a short course of radiant heat and light massage to the scalp

in the region of the skull defect should be given preparatory to operation. This will frequently light up a focus of latent infection, should such be present, and will thus help to avoid operation on a skull defect in which sepsis lies hidden in the tissues only to flare up when the operation is performed. In this series of cases repair was not undertaken until at least three months after the scalp had been soundly healed. However, if the scalp is healthy and the above precautions are observed, it has been found that 'grafting' can safely be undertaken in certain cases at a much earlier date.

Many old cases of brain wound have a paper-thin epithelial scar overlying the defect, and radiating scars over a wide area of the scalp. The very thin scar will undergo avascular and pressure necrosis when lying over a graft, and for this reason primary plastic operation on the scalp may be needed first for excising the scar and obtaining full-thickness scalp to cover the graft.

With large defects the making of a plaster moulage which shows the defect and includes the comparable area on the other side of the head may be helpful during the laboratory process in reproducing the correct contour in the 'graft'. It may also be necessary for specially shaped impression trays to be made for use during the operation.

The technique of producing the acrylic plate is an adaptation of the methods used in the construction of dentures, and requires at least four hours' laboratory work in order to produce the finished article. Up to the time of writing, this time factor has entailed a two-stage operation for the repair of cranial defects by this method.

**Surgical Procedure**—A scalp flap is utilized to give full exposure of the cranial defect and its adjacent area. With the widespread radiating scars often seen in these cases, this may not be a simple consideration. Great care is needed in planning the incision for the scalp flap in order that all portions of the flap have an adequate blood-supply. Unless this is done the flap margin may undergo necrosis to varying depths, and at best this will leave a wide bluish-white epithelialized scar always devoid of hair and so spoil in part the cosmetic result of the operation. To avoid this marginal necrosis, standard direction of scalp flaps must often be ignored, and a wide-base pedicle must contain the maximum blood-supply obtainable, and at no point should the old scar reach the flap incision.

The margin of the bone defect and about half an inch of adjacent skull around it are cleared of fibrous tissue and pericranium. The fibrous tissue which is in continuity with the pericranium is attached to the dura or fibrous tissue which has replaced a dural deficiency and needs to be cut away from this. A step is then cut with a mallet and chisel right round the bone of the defect margin. The bone removal is about half the skull thickness and from  $\frac{1}{4}$  in to  $\frac{3}{8}$  in in width. Sharp definition of angles and walls should be aimed at, as this will greatly facilitate the production of a firmly fitting acrylic plate. After hæmostasis, an impression of the bony margins of the defect is obtained. When taking the impression, its removal will be facilitated if the bony margins are previously moistened with a trace of sterile liquid paraffin.



The impression material which has been used for this purpose is Zelex. This hydrocolloid material, which is gelatinous calcium alginate, was selected for several reasons. It is easily sterilized in its

the presence of any undercuts in the bone margin during withdrawal.

Zelex is prepared immediately before use by mixing the sterilized powder with cold sterile water



FIG 102—Case 6632. Four months after penetrating head injury due to land mine explosion. Showing left frontal skull defect, 7 x 6 cm in size, involving supra orbital margin.



FIG 103—Case 6632. The margins of the bone defect have been exposed and the step is about to be cut.



FIG 104—Case 6632. Illustrates the taking of the impression. Excess of the hydrocolloid is seen at the margins of the metal tray.



FIG 105—Case 6632. Removal of the Zelex impression after setting. The step preparation of the defect margin can be seen.



FIG 106—Case 6632. The acrylic plate in place showing well the remodelled supra orbital margin (arrow) and the excellent fit obtained.



FIG 107—Case 6632. The post-operative result.

powder form by autoclaving at 15 lb pressure. Minimum pressure is necessary in the application of this material to obtain an impression, so that unnecessary pressure on the dura and brain is avoided. Another great advantage is that when set it is elastic and does not therefore get broken or distorted by

to the consistency of thick cream. To obtain the impression the prepared material is placed upon a suitable tray, of which varying sizes and shapes should be available, in certain cases a special tray will need to be prepared. This tray must be sufficiently rigid in construction to avoid distortion during the

taking of the impression, otherwise moulds made from the impression will not be an exact reproduction of the defect. The surface of the chosen tray

because from this it will be possible to make an acrylic plate which will conform to the curvature of the surrounding bone. On removal the impression



Fig 108



Fig 109

FIGS 108-110—Case 9557. Three months after through and through shell wound of the frontal region which caused gross comminution of the frontal bones and floor of the anterior fossæ. Lacerated brain and bone fragments were removed and a fascial repair of the dura carried out at the primary operation. Size of skull defect 15 × 9 cm.



Fig 110



FIG 111—Case 9557. Shows acrylic plate in place. Note the perforations.



Fig 112



Fig 113



Fig 114

FIGS 112-114—Case 9557. Post-operative photographs and radiograph. Fig 113 shows the step-cut of the bone margin and demonstrates the radiolucency of acrylic resin. (Lt-Col C A Calvert's case)

is coated with hot dental wax, to which the Zelex will adhere. The impression tray with its thick layer of Zelex is pressed steadily into place and then gently held there for four minutes before removal. The impression must include an area of bone at least an inch away from the free margin of the defect,

is washed free of any blood and immersed in a bowl of saline in which it is conveyed to the laboratory (Figs 102-105). A description of the method of processing the acrylic plate is given later.

The scalp is then sutured back into position with a single layer of sutures to await the

preparation of the 'graft' and its insertion as a second stage

The insertion of the acrylic plate is usually carried out on the following day, using local anaesthesia. The scalp flap is again turned down, and the acrylic plate, after sterilization by boiling for 30 minutes, is dropped into place, it fits the defect and step exactly. It is held in its seat by suturing one or more pericranial flaps across its surface. Calcium penicillin-sulphamezathine powder should be added to all layers and the scalp closed in the usual two layers without drainage. It has been thought advisable to have several perforations in the plate to allow any possible blood or fluid collections beneath it to escape from the extradural space (Figs 106-114)

### IMMEDIATE CLOSURE OF OPERATIVE DEFECTS

Some cases with a skull defect have some underlying cerebral pathology requiring treatment. In this series, 5 of the 25 cases had such a condition, all 5 had a cerebral scar, 4 with retained bone fragments resulting from a penetrating wound. Two of the 5 had a small abscess within the scar. In all these 5 cases the intracerebral work was done via the bone defect, which was enlarged freely to give adequate exposure. The brain scar, with retained bone fragments, was excised *en bloc*, together with adherent dura. The dura was reconstituted with fascia lata and an acrylic 'graft' used to fill the bone defect.

In such operations there can be no preconceived idea of the size or shape of the eventual bone defect, so that acrylic or tantalum plates made to an impression of the skull defect via the scalp before operation cannot be used, and bone-grafting at the end of such operations is an unjustifiable added risk. For these cases the method described for skull defect closure is ideal.

### BEHAVIOUR OF THE 'GRAFT'

There is little more fluid tissue reaction around acrylic plates than around rib grafts, whichever method is used, aspiration of fluid from beneath the scalp is usually necessary in the days following operation. In acrylic 'grafts' aspiration has never been necessary after the fifth day, and the fluid has always been sterile. In 2 cases the cytology of the fluid was followed.

Case A—	Red Cells	Polymorphs	Lymphocytes
1st post-operative day	57,000	410	80
2nd " "	36,400	1,000	80
3rd " "	25,650	370	30

Case B—	White cells	uncountable
1st post-operative day	250 000	due to clot
2nd " "	58 600	2,960
3rd " "	22,500	60

Electro-encephalographic records over the 'graft' are considerably flattened by the increased resistance of the acrylic plate. In 1 case in which the condition was definitely investigated, it was found that by increasing the amplification three times a record was produced identical with that seen before operation, showing that the physiological activity was probably unchanged.

### RESULTS

Of the 25 cases of skull defect repaired with acrylic plates, 24 have made perfectly satisfactory progress and have at no time given rise to any anxiety. At the time of writing the longest follow-up on a case has been twenty-four months. This case was an excellent test because in this instance the 'graft' was in contact with the frontal sinus, separated from it only by a muscle-graft. It has never caused any trouble whatsoever.

One patient had a generalized epileptiform convulsion on the fifth post-operative day. He had not had a convulsion before operation. The original injury was seven months prior to operation for repair of the skull defect and caused marked cortical damage in the left fronto-parietal region. It is probable that the patient would have suffered this epileptiform convulsion in any case, but it was on the basis of a possible extradural collection of fluid beneath the 'graft' causing local pressure that it was decided to have one or more perforations in these plates to allow of escape to the surface of such accumulations.

The cosmetic results were extremely satisfactory in all cases. Although previously the patients all had a very conspicuous and disfiguring deformity of the head, after operation no abnormality in outline could be detected. It is because of the ease with which it enables one to reproduce any desired shape or outline that this method is particularly indicated for defects encroaching on the nasal and orbital regions.

One of the 25 cases was a failure and is reported here with observations on the causes. This patient originally received operative treatment in 1941 for a large subdural haematoma which became infected. As a result he was left with a large bone defect overlain with a thin T-shaped scar. The wound had been healed for two years when repair was undertaken. Tissue removed from the thickened dura at the time of operation contained small sterile fluid loculi, and on microscopy areas of infiltration by macrophages and foreign-body giant cells. Sixteen days after operation a *Staph. albus* infection developed beneath the scalp. This responded well to local penicillin instillation, but the T-scar broke down by necrosis at its junction point, exposing the surface of the acrylic plate. With infection controlled, it was interesting to observe granulation tissue beginning to grow across the plate in an attempt to fill the defect. Although this was never attained, it is evidence of lack of gross cytotoxic activity of acrylic resin. The removal of the 'graft' was, however, necessitated some two or three weeks later by further infection.

This failure shows many points of importance to be considered carefully when undertaking repair of skull defects in cases in which there has been sepsis at a previous date. It seems very probable that in this case there was a definite latent infection within the fibrous tissue of the dura which became activated by the operation. The inflammatory reaction caused increased tension of the scalp, with consequent pressure necrosis at the vulnerable T-junction of the old scar, which was very thin when 'grafting' of the skull was commenced. It is noteworthy that in this case there was no pre-operative

radiant heat or massage, as already indicated, such a precaution might well have revealed the likelihood of a possible flare-up of latent infection

are being made in the operative and laboratory techniques. Examples of this are the special pre-operative care of scars overlying defects, and the

## PRODUCTION OF THE ACRYLIC 'GRAFT'

The mechanical process of making the 'graft' can be carried out with the materials and apparatus found in most dental laboratories, with the exception that for any defect which is larger in area than a denture a specially made large metal flask will be required

As soon as the impression is received in the laboratory a model of the bony defect is cast from it in artificial stone. A pattern of the proposed 'graft' is then built up in wax to fit this model and is carved and moulded to any desired shape and contour. A two-part mould is then prepared around this pattern, the two halves of this mould are separated, and the wax is removed. The mould is then packed with a doughy mixture of acrylic resin. This is condensed thoroughly, the mould is closed and heated in boiling water to polymerize and harden the acrylic. These are the main principles of the method, a brief pictorial description of the various steps in the laboratory technique is shown in Figs 115-123. For further details standard books on dental prosthetics should be consulted

A few improvements in technique should be mentioned here. Impression trays with a central 'window' cut out were found to minimize pressure on the dura and to prevent pulsation of the brain spoiling the impression. The use of stone models in preference to plaster is advised, and to avoid errors due to shrinking and warping when using large areas of wax it was found essential to process on a duplicate model. Finally, sterilization of the acrylic by boiling should be carried out with the 'graft' seated in the master model

## DISCUSSION

We first started using this method in July, 1943. At that time, although little had been written about it, it was known that acrylic resin had been used for repair of skull defects, both in this country and in U.S.A., and that the method was usually that of adapting a piece of manufactured acrylic sheet at the time of the operation by heating and bending to shape. The more reliable method we have described of direct impression-taking and the use of a mould-treatment is an application of the accurate procedures of dental prosthetics. The authors have had no opportunity for very thorough investigation of the literature, but it seems probable that other workers have proceeded along the same lines in evolving a method for cranial repair. A similar technique was described by Shelden, Pudenz, Restarski, and Craig for making an acrylic calvarium to be used for direct observation of the brain in monkeys (1944).

Although this method of repairing skull defects has already given very satisfactory and useful results, we realize that there is still much room for further development, and from time to time, as a result of experience, certain changes and improvements

drainage holes now made in the acrylic plates, the latter precaution being necessitated by the accuracy of fit between bone and plate. And now experiments have been made, with some success, in reducing the time of the laboratory technique and so enabling the operation to be completed in one stage



FIG 115 — Pouring 'artificial stone' into impression of bone defect. Bone defect in this case measured 10 x 11 cm



FIG 116 — Resulting master model after removal of hydrocolloid, showing reproduction of dural depression and undercuts beneath bony margin



FIG 117 — Right, Master model with depression and undercuts filled in with wax, the surface of which corresponds to the estimated plane of the inner surface of the lost bone. Left, Impression of corrected master model taken in dental composition to produce duplicate working model

In the technique here described the special processing of the material has necessitated a two-stage operation. This is an inconvenience, although in practice we

should not be carried out at the emergency operation and the acrylic plate prepared and 'filed' for future use.

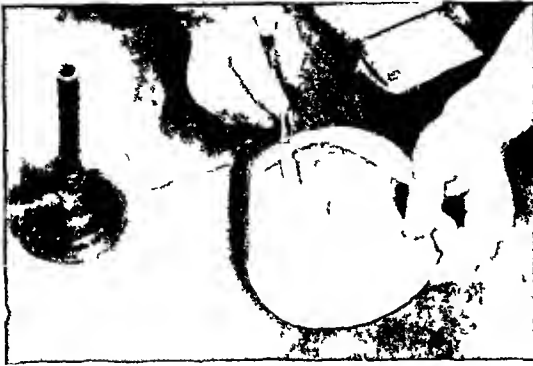


FIG 118—Working model, cast in stone, having 'bone defect' restored in wax. The surface is built up and conformed to the curvature of the surrounding surface of the model, reproducing the correct shape of the lost bone. This wax pattern is then duplicated in acrylic resin by the method used in the processing of dentures.

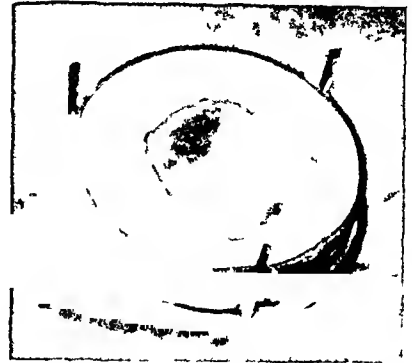


FIG 119—Working model and wax pattern invested in lower half of specially made copy of the standard denture flask. The surface of the surrounding plaster is oiled, the upper half of the flask filled with plaster of Paris, and while this is still soft the flask is closed.

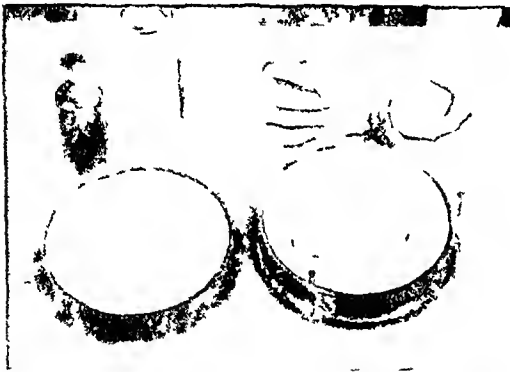


FIG 120—After opening flask and removal of wax pattern the resulting space in the mould is being packed with the plastic mixture of the polymer and monomer.



FIG 121—Clamping the two halves of the mould together. Curing is completed by placing the flask in boiling water for an hour. After thorough cooling the acrylic is removed from the mould.



FIGS 122, 123—After trimming and polishing, completed graft with master model.

have considered it to be outweighed by the excellent cosmetic results obtained.

In selected cases, where primary healing is anticipated, there is no reason why the first stage—that of step-cutting and impression-taking—

Unlike many other materials used for skull repair, acrylic resin is radiolucent (see Fig 113), and we consider this to be a very important point in its favour. Many of the cases undergoing treatment will require periodic neurological examination, and

# SURGICAL TREATMENT OF TRAUMATIC ANEURYSMS 113

a material which owing to its opacity interferes with the taking of radiographs and encephalograms has serious disadvantages

## SUMMARY

- 1 A method is described of repairing cranial defects with acrylic resin
- 2 The properties of this plastic are discussed. It is shown to be a tough, light-weight, inert, radiolucent, and adaptable material which seems particularly suitable for this purpose
- 3 The necessity for closure of bony defects in the skull is considered
- 4 The particular advantages of this method in operative defects is emphasized, as also is the ease with which large bone defects and defects encroaching on areas of irregular contour can be accurately restored
- 5 Precautions regarding planning the scalp flap and the condition of the scalp are stressed, with special reference to pre-operative massage and radiant heat and to the excision of doubtful scars

6 Operative details are given and the laboratory technique summarized

Our thanks are due to the Officer Commanding this hospital for permission to publish this paper, to Brigadier Hugh Cairns for his encouragement and helpful criticism, to S/Sgt L G Martin, E L P Tugwell, R A M C, for preparing the photographs

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# THE SURGICAL TREATMENT OF TRAUMATIC ANEURYSMS

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The surgical treatment of large aneurysms is fraught with difficulty and danger, and the successful management of such cases demands a high degree of technical skill together with a proper appreciation of the problems of this branch of surgery. The recording of these cases serves to indicate how problems have been met in individual instances, and such experiences are worthy of record as they are not so common as to be within the experience of most surgeons.

The surgical treatment of aneurysms dates from early times, and in the original operation of Antyllus the sac was laid freely open, all the blood and clot within the sac was turned out, and each end of the artery entering and leaving the aneurysm tied in surgery, and up to the days of Hunter many bold surgeons preferred to amputate the limb rather than expose the patient to the enormous primary and secondary risks, from hæmorrhage, diffuse cellulitis, and gangrene. Percival Pott spoke of the event of operation as 'always fatal' and Hunter had not a single successful case" (A Pearce Gould, 1895). It is not surprising that the surgeons of those days sought for less drastic methods of curing aneurysms. Diminution of the flow of blood through the aneurysm by ligature of the artery was a simple expedient, and the most effective site for such a ligature of the artery would be just above its point of entry into the aneurysmal sac. This operation was introduced by Anel in 1710, but it did not receive full acceptance owing mainly to the dangers of approach to the artery so close to the sac, dangers much increased when operations were performed in the days before Lister revolutionized surgery. Hunter (1785) ligatured the femoral artery and vein in Hunter's canal for an aneurysm

of the popliteal artery, introducing the method of proximal ligature of the main artery well above the aneurysmal sac, and this was considered the method of choice up to the beginning of the present century. Ligature of the artery immediately distal to the aneurysm (Brasdor), and ligature of the artery at a point well beyond its point of exit from the aneurysm (Wardrop) were methods introduced to deal with those cases in which ligature of the artery proximal to the aneurysm was impracticable on account of its anatomical situation. Although cures were obtained by ligature of the artery, such cures were uncertain and failures were not uncommon. The reason for such failure was to be found in the excellent supply of blood still brought to the aneurysmal sac by collateral vessels. There was also the dread possibility of gangrene being produced as a result of ligature of the artery.

The introduction by Matas in 1888 of the operation of endo-aneurysmorrhaphy revived the older method of Antyllus, but operations were now performed with added safety owing to the introduction of Lister's principles of antiseptics and asepsis. Matas introduced three methods, the method of oblitative endo-aneurysmorrhaphy and the methods of restorative and reconstructive endo-aneurysmorrhaphy. The restorative method is the ideal operation, but is only applicable in saccular aneurysms. The reconstructive method which was introduced for fusiform aneurysms had been abandoned on account of the high incidence of post-operative thrombosis in the newly-constructed channel. The method of oblitative endo-aneurysmorrhaphy which is practically the old operation of Antyllus is the method of choice for such cases, and also for those cases of saccular aneurysm in which the arterial wall has been so extensively

destroyed as to preclude the performance of the method of restorative endo-aneurysmorrhaphy. The operation might, however, be attended by formidable and alarming hæmorrhage, even in cases where the circulation through the aneurysm has apparently been controlled by temporary clamping of the main artery above the aneurysm. The surgeon must be prepared to control the blood-loss by introducing his hand through a sea of blood into the aneurysmal sac in order to compress the main artery by digital pressure, from within the sac. Once this has been done and the blood-clots have been wiped away, cautious release of this pressure will reveal the orifices from which the blood will gush, and these orifices can then be closed by suture or ligature. The reinforcement of the suture or ligature line by plying of the aneurysmal wall over it, as described by Matas, is not always practicable as the sac wall lacks the necessary texture and definition to permit of this, being merely made up of laminated blood-clot. In many of the cases described in this paper, this step was omitted without ill effect. In regard to obliterative endo-aneurysmorrhaphy, Gage (1943) writes: "The procedure is of the greatest simplicity. It consists simply of opening the aneurysmal sac and closure of the arterial openings of which there may be several, and then obliterating the sac. The suture material should be either cotton or silk, as absorbable sutures will give way with dire consequences." There is still place for the older operation of simple ligature of the main artery and also for the more drastic modern version of the operation of Antyllus, in which the entire sac is extirpated after ligature of every vessel entering and leaving the sac. Thus Pemberton and Black (1943), in a review of cases treated at the Mayo Clinic, record the method of ligature of the artery and excision of the sac for 4 cases of popliteal aneurysm with satisfactory results in all cases, and the same method for 2 cases of aneurysm of the superficial femoral artery, with gangrene and amputation as a result in 1 case. Gage (1943) considers that Anel's method of proximal ligature of the main artery still has a place in the treatment of aneurysms of the common carotid, subclavian, and external iliac or common femoral arteries. For an arteriovenous aneurysm of the left subclavian artery Touroff (1941) ligatured the first part of the subclavian artery via the transpleural route, using the same approach as he had been using for ligature of the patent ductus arteriosus.

The risk of gangrene of a limb following an operation in which the blood-flow through the main artery has been obliterated by the operative procedure should be minimized as far as possible. If the arteries distal to the aneurysm exhibit a normal pulsation, it is clear that most of the blood is still travelling through the main artery, and in the traumatic cases the aneurysm is likely to be saccular and suitable for treatment by the restorative endo-aneurysmorrhaphy method of Matas, which carries almost no risk of interference with the main circulation through the limb. If, on the other hand, there is no pulse in the arteries distal to the aneurysm, it is clear that the circulation is being mainly carried on by collateral vessels (Delbet's sign) and Matas advocates that the deficiency of the collateral circulation be estimated by the following method. The

limb is blanched by elevating it and by the application of a firm elastic bandage. The main artery is now compressed above the aneurysm, the elastic bandage is removed, and the limb lowered. If the collateral circulation is efficient, there should be a blush in the blanched limb within three minutes. If the collateral circulation be deficient, it can be improved by removing the sympathetic vasomotor control to the limb either by the operation of sympathectomy (Pemberton and Black, 1943), or more temporarily by injection of the sympathetic field with novocain (Gage, 1943).

## CASE REPORTS

### Case 1—Traumatic aneurysm of the right axillary artery

**HISTORY**—C S male, Sinhalese, aged 15 years, was admitted to the General Hospital on July 24, 1944, complaining of severe neuralgic pains radiating down the right upper limb, and a large pulsating swelling below the right shoulder.

Two months previously, while cutting wood in a jungle at Kekirawa, the patient had accidentally struck a metal object, which had exploded. He was wounded in the right shoulder, left knee, and left ankle by pieces of flying metal. The wound of the right shoulder bled profusely and he was admitted to the local hospital, where he was detained for fifteen days. A month after the accident he noted weakness of the right hand, the flexion movements of the thumb and index finger being particularly affected. There was also a lump in the armpit which steadily increased in size.

**ON EXAMINATION**—The boy was seen to be suffering from severe pain. He sat in bed with his right elbow supported in his other hand, groaning in agony. There were two healed scars, each  $\frac{1}{2}$  in long, on the front of the axilla over the pectoralis major muscle, and there was a large swelling bulging the anterior axillary wall from the clavicle down to the floor of the axilla (Fig. 124).



FIG. 124—Case 1. Aneurysm of right axillary artery.

The entire floor of the axilla was bulged downwards by the swelling which extended from the anterior to the posterior walls. The swelling had an expansile impulse synchronous with the pulse, and there was a harsh systolic bruit heard on auscultation over it, conducted down the brachial artery for 2 in. The radial pulse on the right side was about one-third the volume on the left side. The patient was unwilling to move his elbow, but could be persuaded to fully extend and flex it. The movements of the wrist and fingers were unimpaired, except for the movements of flexion of the terminal phalanx of the thumb, and flexion of the index finger, which were weak.



and could only be partially performed. A radiograph of the right shoulder showed a fragment of metal in the axilla.

**AT OPERATION**—Under general anaesthesia on July 28, the third part of the right subclavian artery was exposed in the neck, and a tape was passed around the artery. The artery was temporarily clamped by tying the tape over a piece of rubber tube placed on the artery. The brachial artery was exposed just below the outlet of the axilla, and this artery was also temporarily clamped in the same manner. A curved incision was made on the front wall of the axilla. The sternal fibres of the pectoralis major muscle were divided at their insertion into the humerus, and the aneurysm, which lay immediately behind the muscle, was exposed. The walls of the aneurysm were made up of friable laminated blood-clot. The blood and clots were wiped away and it was noted that there was profuse hæmorrhage from the depths of the wound. This was controlled by pressing the fingers on to the axillary artery. An oval hole was seen in the artery which bled freely when the fingers compressing the artery were released. The hole admitted the tip of the finger. In spite of firm pressure, blood leaked through this hole, causing an appreciable blood-loss. The pulse-rate recorded 200 at this stage, and a blood transfusion of two pints was given. Attempts to close the hole with interrupted vaselined cotton thread sutures were not successful as the hole was too rigid to allow of this. The edges of the hole were apposed by clamping them with Spencer Wells artery forceps, and ligatures were tied below the forceps. There was no bleeding now, and on releasing the temporary ligatures on the subclavian and brachial arteries, the wound remained dry. It was now noted that there was good pulsation, of the same volume as the other side, in the right radial artery. The pectoralis major muscle was repaired by suturing its cut surfaces with catgut and the skin wounds were closed.

**PROGRESS**—The patient made an uninterrupted recovery from the operation. After the skin sutures were removed, it was noted that he could not abduct



FIG 125—Case 1 After operation for right axillary aneurysm

his shoulder, but this corrected itself in a few days (Fig 125). At the time of leaving hospital on Aug 18 there was still weakness of flexion of the index finger and thumb. The axilla has a normal contour, and the bruise over this area had disappeared. The pulse in both radial and ulnar arteries were of full volume and of the same force as of the opposite side. An X-ray picture taken before the patient left hospital showed that the piece of metal in the axilla was no longer present. It had probably been wiped out in the masses of blood-clot removed at operation.

### Case 2—Traumatic saccular aneurysm of the left common carotid artery

**HISTORY**—S, aged 25 years, male, Sinhalese, was referred to the General Hospital, Colombo, from the District Hospital, Deniyaya, on account of aphonia, paresis of the right hand, and some impairment of the mental function following a stab wound in the neck four months ago. There had been some surgical emphysema around the wound at the time of injury.

**ON EXAMINATION**—The patient made unintelligible sounds on attempting to talk, and the history had to be taken from his mother, who stated that the patient had been stabbed in the neck four and a half months ago. There was a scar on the neck horizontally disposed at the level of the cricoid membrane, running from a point over the left sternomastoid muscle to just short of the middle line. There was no visible swelling in the neck and no distended veins. On palpation, a lump the size of a walnut was felt underlying the scar, and the lump exhibited an expansile pulsation synchronous with the pulse. A fine purring thrill was felt over the lump, and also over the left carotid and left subclavian arteries. On auscultation, a loud continuous murmur was heard like the sound of thunder, with an exacerbation at each systole of the heart. This murmur was heard most loudly over the left carotid and subclavian arteries, but it was also heard with lesser intensity over the manubrium sterni and the right carotid and subclavian arteries. The larynx and trachea were not displaced by the lump. The apex beat was palpable in the fifth space in outside the nipple line. The heart-sounds were normal. Blood-pressure 130/80. There was a notable weakness of grasp in the right hand. There was no weakness in the facial muscles or the muscles of the lower limb, nor was there any abnormality in the reflexes of the limbs, except for briskness of the knee-jerk on the right side. There was no loss of sensation. The left palpebral fissure was slightly narrower than the right, and the left pupil slightly smaller than the right. Both pupils reacted to light. There was no evidence of increased sweating on either side of the head or face. Indirect laryngoscopy showed the left vocal cord to be paralysed and lying in the adducted position.

It was apparent that the patient had developed an aneurysm of the left common carotid artery as a result of the stab wound. The absence of dilated veins in the head and neck negated the possibility of an arterio-venous communication. The paralysis of the left vocal cord and the enophthalmos and small pupil on the left side pointed, respectively, to involvement of the left recurrent laryngeal nerve and the left sympathetic cord in the neck, either from the knife wound or from pressure of the aneurysm. The paresis of the right hand was possibly due to an embolus liberated from the aneurysm and lodging in the left side of the brain.

**FIRST OPERATION** (Nov 3, 1939)—An incision was made along the anterior border of the left sternomastoid muscle, and the carotid vessels were exposed. There was an aneurysmal sac, the size of a walnut, on the outer side of the common carotid artery, displacing the internal jugular vein outwards (Fig 126). The sac was carefully isolated, and it was found to have a narrow neck arising from the common carotid artery. The neck of the sac was cautiously ligatured with two silk ligatures. At this stage the sac was noted to be flaccid. The wound was closed.

**PROGRESS**—The day after the operation, the patient was able to whisper intelligibly, and even produce a slight sound in his voice. The thrill over the carotid vessels persisted, as did the murmur, but it was of lower intensity than before. At the time of leaving hospital on Dec 13, the patient could speak in a thin voice.

He was re-admitted on Jan 16, 1940. The scar was keloidal. There was no lump in the neck. The fine thrill was still present, but the murmur was only heard over the arteries of the left side of the neck.

Blood-pressure, 110/70 Apex beat still 1 in outside nipple line. No weakness in right hand. Voice almost normal, but indirect laryngoscopy showed that paralysis of the left vocal cord still persists. A second operation was advised as the persistence of the thrill and murmur was considered unsatisfactory.

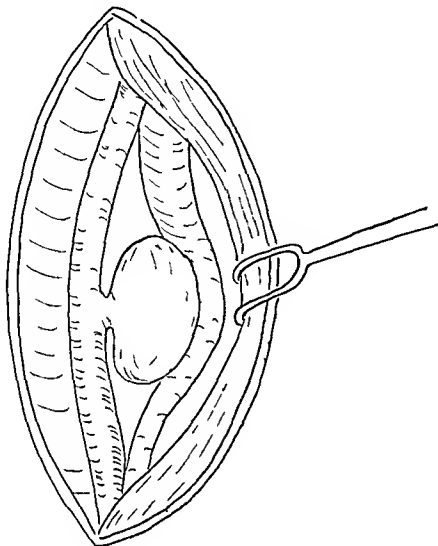


FIG 126—Case 2. View at operation of saccular aneurysm of left common carotid artery.

**SECOND OPERATION**—This was performed on Jan 19. The keloided scar was excised and the left common carotid artery exposed. There was now no trace of the aneurysm. The common carotid artery was, however, dilated to twice its normal diameter (Fig 127). There was a good deal of scarring in the tracheo-oesophageal groove. The site of the aneurysm on the outer side of the left common carotid artery showed that the knife had pierced the outer wall of the left common carotid

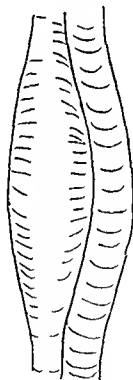


FIG 127—Case 2. View at subsequent operation showing diffuse dilatation of left common carotid artery after excision of saccular aneurysm.

artery only, and it was therefore clear that the left recurrent laryngeal nerve could not have been severed by the knife. It was most probably involved by scarring on the tracheo-oesophageal groove. The persistence of the thrill and murmur was probably due to the diffuse dilatation of the carotid artery following the ligation of the aneurysmal sac.

**PROGRESS**—The patient was re-admitted to the hospital on Sept 17, 1944, for a follow-up examination. He

was in good health and his voice was normal. The scar in the neck was no longer keloided and was not noticeable. There was no thrill or murmur over the vessels of the neck (Fig 128). The apex beat was still

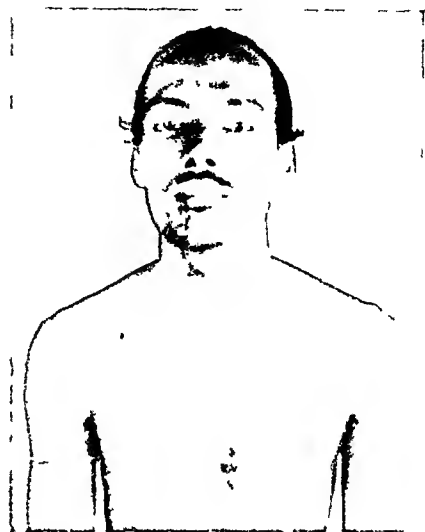


FIG 128—Case 2. The patient after operation. The operation scar and evidence of Horner's syndrome are seen in the photograph.

1 in external to the nipple. There was still slight enophthalmos on the left side, and the left pupil was slightly smaller than the right. There was no weakness of the limbs, and the reflexes showed no abnormality. Indirect laryngoscopy showed that the left vocal cord was still paralysed.

### Case 3—Traumatic saccular aneurysm of the right popliteal artery

**HISTORY**—P. A., male, Sinhalese, aged 35 years of age, admitted to the General Hospital on Sept 2, 1937,



FIG 129—Case 3. Aneurysm of popliteal artery.

on account of a large swelling at the lower end of the right thigh (Fig 129). Five months previously, while climbing a coco-nut tree, the patient had accidentally injured himself by sustaining a stab wound on the inner

# SURGICAL TREATMENT OF TRAUMATIC ANEURYSMS 117

side of the lower end of the right thigh. The wound had bled profusely at the time, but had healed uneventfully. A week after the injury the patient noted a swelling in the right thigh which gradually increased to its present size—that of a grape-fruit. There was now severe pain in the back of the knee, and he had to walk with a limp with the lower limb everted in order to avoid pain, as inversion of the limb increased the pain.

ON EXAMINATION—A large spherical lump was seen on the inner side of the thigh extending from the upper half of the popliteal space up to the middle of the thigh. The swelling had an expansile pulsation synchronous with the pulse. There was a scar  $\frac{1}{2}$  in long in the front of the thigh overlying the swelling. The sartorius, gracilis, semitendinosus, and semimembranosus muscles were behind the swelling and overlaid it in the popliteal space. On auscultation a systolic bruit was heard over the swelling. The pulsations of the dorsalis pedis and posterior tibial arteries were good. It was clear that the patient had developed a large traumatic aneurysm of the popliteal artery.

AT OPERATION—Under general anaesthesia on Sept 10 a tourniquet was applied round the upper end of the thigh, and an incision made upwards from the adductor tubercle along Hunter's canal.

there was a discharge of pus from the wound of the inner side of the thigh. This ceased after some days. At the time of his discharge from hospital on Oct 27 the wounds had healed (Fig 132). The patient was able to extend

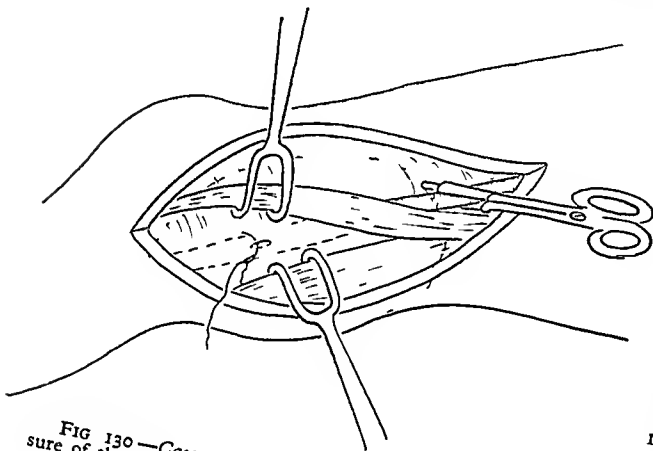


FIG 130—Case 3. Operation view of intrasaccular exposure of the hole in the popliteal artery. The outline of the sac is shown in dotted lines.

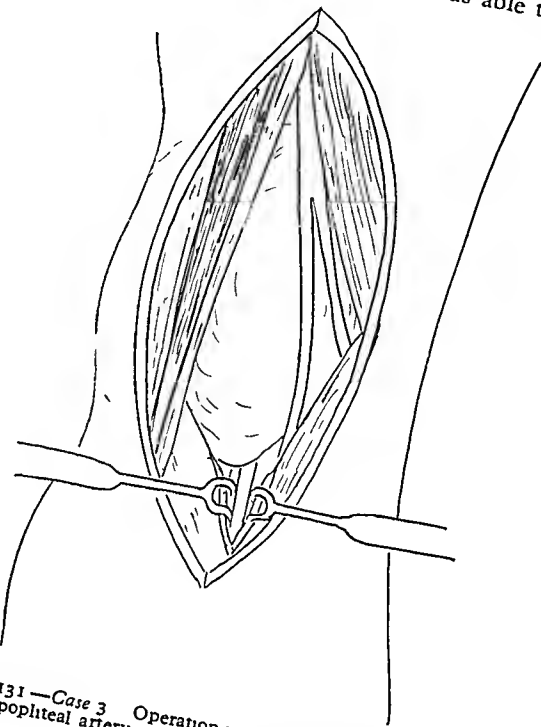


FIG 131—Case 3. Operation view of the aneurysm of the popliteal artery exposed by a posterior incision.

the knee fully, and could flex the knee from this position through a range a little greater than a right angle. He was able to walk well, the foot was warm, and there was no swelling of the foot. The swelling produced by the aneurysm was no longer present.

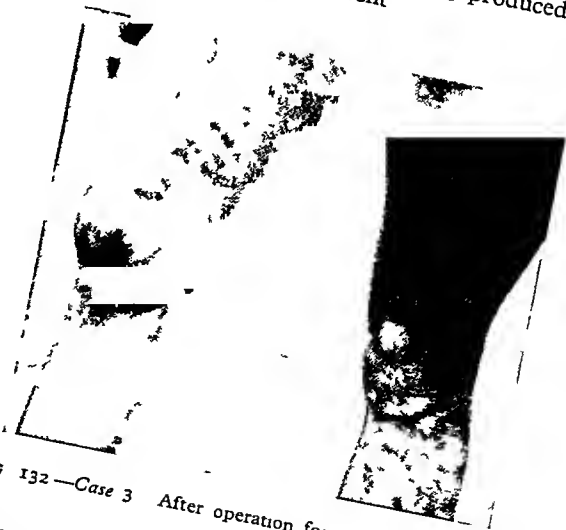


FIG 132—Case 3. After operation for popliteal aneurysm.

The femoral artery was exposed in Hunter's canal and temporarily clamped. The aneurysmal sac was seen to lie behind the adductor magnus muscle in the popliteal space (Fig 130). An incision was made posteriorly over the popliteal space. The medial and lateral popliteal nerves were identified as they lay on the surface of the aneurysmal sac, and they were retracted to the lateral side. The popliteal vessels were identified at the lower pole of the aneurysm (Fig 131) and were temporarily clamped. The first incision on the inner side of the thigh was reopened, and the aneurysmal sac exposed behind the adductor magnus muscle. The sac wall was white. The sac was opened and the laminated blood-clot and blood wiped away. The popliteal artery was seen on the further wall of the sac and it had a hole in its wall, which admitted the tip of the finger (Fig 130). This hole was closed with interrupted sutures of fine vaselined silk, and the suture line was reinforced by pleating some of the adjacent wall of the aneurysm over it. The clamps on the femoral and popliteal vessels were released and the tourniquet removed. There was no bleeding. The wound was closed.

PROGRESS—After operation the pulse was 104, and there was good pulsation in the dorsalis pedis and posterior tibial arteries of the same foot. On Sept 27 VOL XXXIII—NO 130

Case 4—Traumatic aneurysm of the third part of the axillary artery. HISTORY—J A V A, male aged 25 years, Sinhalese, was admitted to the General Hospital, Colombo, on Nov 11, 1943, on account of a lump in the left armpit and severe neuralgic pains shooting down the left upper limb. Twenty-four days previously the patient had been

stabbed in the front of the left shoulder. The wound had bled profusely and he stated that he had lost consciousness. When he recovered he found himself in the local hospital, where his wound had been sutured. During the next five days the wound was apparently healing uneventfully, but on the sixth day he noted a lump in the left armpit, the size of a marble. He now had pain radiating down the outer side of the left arm. The lump steadily increased in size, and the pain began to radiate down the forearm also. The pain became more intense, and he now had paralysis of the fingers, wrist, and elbow. He decided to enter the General Hospital.

**ON EXAMINATION**—The patient was seen to be suffering from severe pain and he sat with his left forearm supported in his other hand, groaning with pain. There was a healed scar on the anterior axillary fold, 1 in. in length. He had a wrist-drop on the left side. There was a lump in the left armpit extending from the anterior axillary fold to an inch short of the posterior axillary



FIG 133—Case 4 Aneurysm of the axillary artery

fold. The lump was the size of a tennis ball, and on its summit there was a smaller projection, the size of a marble, which bulged the overlying skin and visibly pulsated (Fig 133). On palpation the main lump had an expansile impulse synchronous with the pulse, and a systolic thrill which was also palpable in the proximal 2 in. of the brachial artery. On auscultation there was a harsh systolic murmur over the same area. Blood-pressure, Right arm, 100/75, Left arm, 95/65. The pulse at the left wrist was of poor volume. The left shoulder-joint movements were of normal range, but were difficult to elicit as the patient had poor control of the wrist and elbow. He was, however, able to move his shoulder through its full range. At the elbow active extension was lost. Flexion was normal to 90°, and from this point the arm fell without control into the fully flexed position. He was, however, able to flex the elbow through its full range against resistance. The movements of pronation and supination were clumsily executed. At the wrist-joint there was still full active flexion, but no extension, abduction, or adduction. He was able to flex the fingers strongly, but could not extend them fully. Abduction and adduction of the fingers were weak and were lost for the little finger and thumb. There was loss of sensation to pin-prick and cotton-wool touch over the left thumb and over the left little finger

and ulnar edge of left ring finger together with the adjacent areas of the palm. There was loss of sensation to light touch only on the lateral aspect of the left forearm.

It was clear that the patient was suffering from a traumatic aneurysm of the third part of the left axillary artery, and that the aneurysm was causing harmful pressure on the nerve-trunks.

**AT OPERATION**—Under general anaesthesia on Nov. 22 an incision was made above the left clavicle and the third part of the left subclavian artery exposed in the neck. A rubber tube was passed around the artery. An incision was made in the line of the brachial artery, and the commencement of the brachial artery was exposed. It was found to be reduced to a thin cord, which barely pulsated. The circulation in the subclavian artery was now controlled by clamping the rubber tube tautly round the artery. The incision over the brachial artery was prolonged over the axilla, and the lower edge of the pectoralis major was retracted upwards. The aneurysmal sac was exposed. The nerve-trunks were seen on the surface of the aneurysmal sac, the outer and inner heads of the median nerve being easily identified (Fig 134). The aneurysmal sac was opened and the blood and clots were wiped away. The artery was found to be reduced to a shallow gutter on the posterior wall of the sac, and it was considered irreparable. The

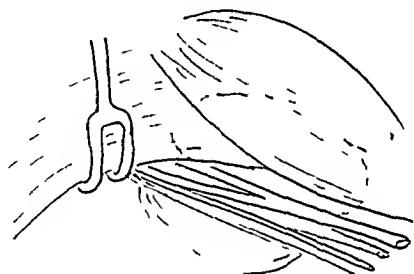


FIG 134—Case 4 Operation view of the aneurysm of the axillary artery

axillary artery was tied from within the sac as it entered and left the sac. The clamps were released and, as there was no bleeding, the wound was closed. After operation the left hand was cold, but by 9 p.m. the same day it had become warm again. There was no pulse at the left wrist.

**PROGRESS**—The patient made an uneventful recovery, but up to the time of his leaving hospital there was no improvement in the weakness of the left upper limb. He was discharged on Dec. 16, with the wound healed and without any recurrence of the aneurysm.

#### Case 5—Traumatic aneurysm of the left femoral artery

**HISTORY**—H. F., aged 35, Maldivian Islander, was admitted on Nov. 28, 1938, complaining of a lump in the left thigh. He had been stabbed in the left thigh with a pair of scissors six months previously. The wound had bled profusely for some time, and the bleeding had then stopped. He had taken to his bed after the accident on account of severe pain in the thigh, and three days later he had noted the lump, which had got slowly larger and larger. The lump was at first more prominent on the inner and posterior aspects of the thigh, and it had slowly enlarged forwards. The wound on the thigh had healed in a month's time, but he had been confined to bed for five months because he was unable to straighten the left knee. In the last month it had been possible for him to straighten the left knee, and since then he had been up and about.

**ON EXAMINATION**—There was a large lump on the inner side of the left thigh, the size of a husked coco-nut, occupying the lower half of the thigh (Fig 135). The

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skin over the swelling was stretched and shiny and many dilated veins were visible through it. The swelling was soft and pointing posteriorly through the skin, which was thinned. The skin was not attached to the swelling except posteriorly. The quadriceps muscle was on the antero-external side of the swelling and the hamstring muscles (semimembranosus and semitendinosus) were displaced to the inner side of the swelling. The swelling did not pulsate, except over the area where it was pointing through the skin, and no bruit was heard on auscultation over it. There was a healed scar 1 in long over the front of the swelling at the site of the stab wound. The common and superficial femoral arteries showed good pulsation in Scarpa's triangle. No pulsation was detected in the popliteal artery, the dorsalis pedis artery, or the posterior tibial artery. Obliteration of the femoral pulse below the groin caused no appreciable diminution in the size of the lump. The foot and leg appeared normal. There was no oedema, the skin was warm, and there was good power in all the muscles. Palpation of the bones of the lower limbs showed no abnormality. Movements at the hip- and the knee-joints were of full range, and the

satisfactory as the walls of the aneurysm were friable and widely separated. When these sutures had been applied and the clamp on the femoral artery was released, alarming hæmorrhage immediately occurred and the clamp on the artery was re-applied. It was now decided to ligature



FIG 136—Case 5 After operation for aneurysm of the femoral artery

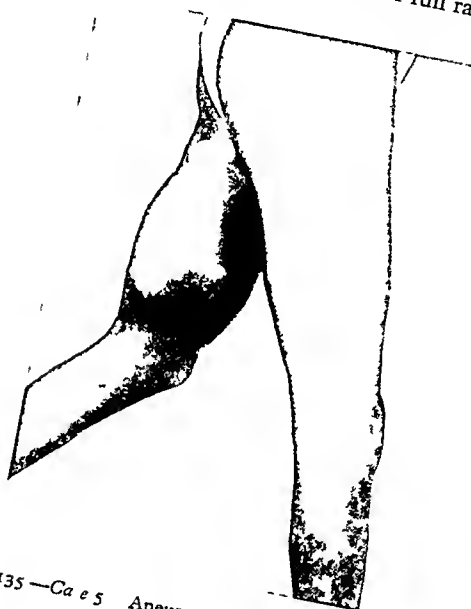


FIG 135—Case 5 Aneurysm of the femoral artery

the femoral artery at the site of the clamp. When this had been done the wound remained dry and the long skin incision was closed. The foot remained warm after the operation and the patient made an uninterrupted recovery. He left hospital on Jan 14, 1939, cured of his aneurysm and able to walk freely and without pain (Fig 136).

**Case 6—Traumatic aneurysm of the right femoral artery\***  
**HISTORY**—A S, male, Sinhalese, was admitted on April 17, 1937, on account of a large swelling of the right thigh and on account of intense pain in this swelling.

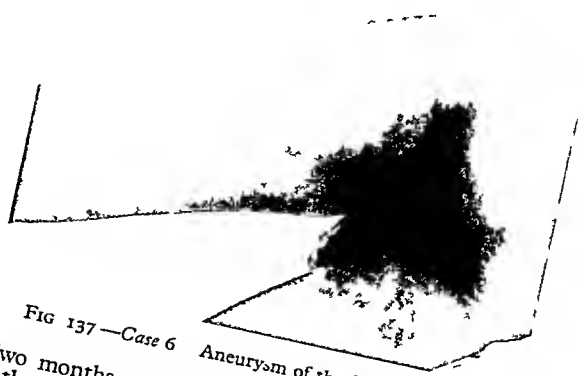


FIG 137—Case 6 Aneurysm of the femoral artery

patient walked without a limp. A radiograph, taken on Nov 29, showed appearances compatible with aneurysm. There was slight erosion of the shaft of the femur. The history and the physical signs pointed to a diagnosis of traumatic aneurysm of the femoral artery in the lower half of the thigh.

**AT OPERATION**—On Dec 2, under spinal anaesthesia, a tourniquet was applied just below the groin and a long incision was made in the line of the femoral artery. The femoral artery was exposed at the apex of Scarpa's triangle and was temporarily clamped at this point. The incision was now deepened, and the aneurysm laid open. It was mainly filled with red blood-clot, which was scooped out by hand. On wiping the wound dry, the femoral artery was seen lying deeply on the posterior wall of the aneurysm. The artery was traced downwards, and at the level of the old stab wound it was found that the wall had been lacerated widely over a length of 1½ in. The tourniquet was now released, but the clamp on the femoral artery was retained. The wound remained dry. An attempt was made to reconstruct the arterial lumen by suturing the wall of the aneurysm over a rubber tube inserted into the lumen above and below the damaged area. This was not

Two months previously he had been stabbed in the right thigh. About ten days after the stab, when the wound had healed, he noticed that there was a swelling in the right thigh. The swelling had gradually got larger and had reached its present size about fifteen days ago. He had suffered a good deal from great pain on the inner side of the swelling, the pain shooting down to the knee.

On account of the pain he was obliged to keep his hip semiflexed.

\* Previously reported in *J Ceylon Br Brit med Ass*, 1937, July

ON EXAMINATION—A large swelling was seen in the front of the right thigh, extending from Poupart's ligament down to the middle of the thigh, where it ended in an elongated tail, running down Hunter's canal (Fig 137) The scar of the stab,  $\frac{3}{4}$  in long, lay transversely

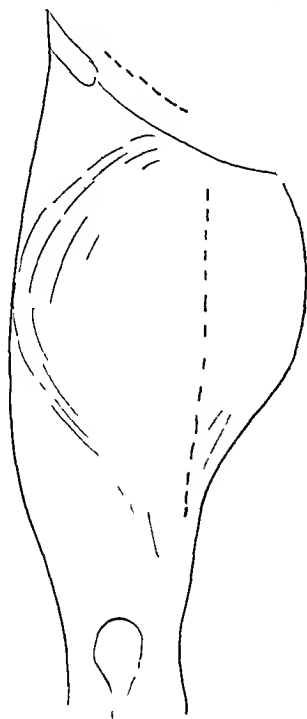


FIG 138—Case 6. A diagram showing the outlines of the aneurysmal sac and with the positions of the incisions made at operation shown by dotted lines

on the front of the thigh at a point 2 in below the anterior superior iliac spine. The skin over the swelling was stretched, tense, and shiny, and there were enlarged veins under the skin. The overlying skin pitted on pressure and the swelling was tender and soft. Over the inner aspect of the swelling, in the upper part of the thigh, was a well-marked palpable thrill. The swelling was noted to have a slight pulsation difficult to detect, but definitely present. A systolic bruit was heard over the swelling, but it was best marked over its upper inner aspect. The popliteal and the anterior and posterior tibial arteries were noted to have a normal pulsation. There was no œdema of the foot or leg, no paralysis of the muscles of the foot or leg, nor of the quadriceps or hamstring muscles, and no impairment of sensation on testing with cotton-wool.

The large swelling, with its palpable thrill and systolic bruit, pointed to the diagnosis of an aneurysm of the femoral artery. The stab wound and the history indicated clearly that the aneurysm was traumatic. A diagnosis of abscess was considered in view of the tense shiny skin over the swelling, the tenderness and warmth of the swelling, and the possibility of the infection having started from the stab wound, but the points already mentioned earlier made this unlikely.

AT OPERATION—Under general anaesthesia on April 22 Stage 1. The right external iliac artery was exposed by Sir Astley Cooper's method, and a temporary clamp was placed on the artery above the origin of the deep epigastric artery. During the exposure of this vessel the purple walls of the aneurysm were visible, bulging upwards through the fat, deep to Poupart's ligament.

Stage 2. An incision was made over the lower end of Hunter's canal. The femoral artery was exposed in

Hunter's canal and a temporary clamp placed on this vessel. During the exposure of this artery the subcutaneous tissues were noted to be œdematous.

Stage 3. Exposure and incision of the aneurysmal wall. The incision over Hunter's canal was prolonged upwards, the entire length of the thigh, in the line of the femoral vessels (Fig 138). The aneurysmal sac was opened in the line of the skin incision. The walls of the sac consisted of laminated layers of organized blood-clot (Fig 139). When this was scooped out there was an alarming hæmorrhage, filling the large cavity with blood in a few seconds. The fingers of the operator were plunged through this sea of blood on to the femoral artery at the level of the stab wound, and the artery was compressed against the adductor muscles of the thigh for several inches of its course. This manœuvre arrested the flow of blood. The blood was mopped out of the large cavity and the femoral artery was inspected. There was an oval hole, the size of the tip of a finger, lying vertically on the antero-external aspect of the superficial femoral artery. The edges of the hole were smooth and lined by endothelium. Five fine silk sutures, No 00, well vaselined, threaded on a fine round-bodied needle, were inserted through the edges of the hole in the artery and tied securely. The hole was now closed. On releasing the digital pressure over the femoral artery no bleeding occurred in the wound. The clamps on the external iliac and femoral arteries were cleared. The wound remained dry. The extensive incisions were now closed without drainage.

PROGRESS—The patient's pulse after the operation was 148, but it was of good volume. There was good pulsation in the dorsalis pedis artery, and the foot and

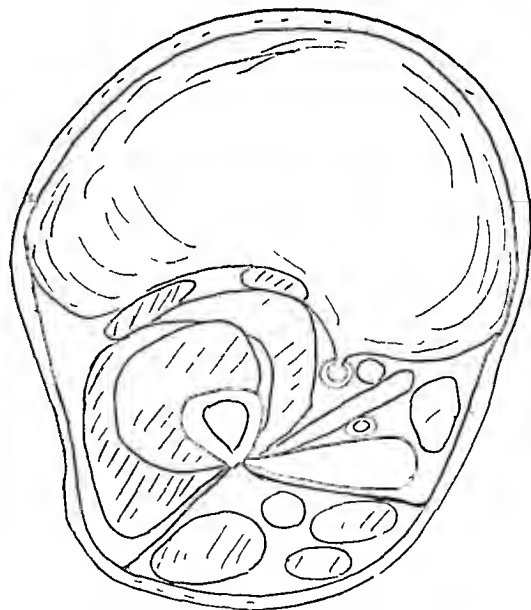


FIG 139—Case 6. A diagram showing the relations of the aneurysmal sac in a cross section of the thigh

leg were quite warm. The patient was nursed with his limb absolutely immobile between two sandbags. He developed slight œdema of the right foot for a few days, but the pulsation in the dorsalis pedis remained good and the foot remained warm. Ten days after operation the patient noticed on getting up in the morning that he was unable to move his left lower limb, which was painful.

The limb was swollen and the inguinal glands were enlarged and tender. There was an elongated zone of tenderness in the line of the long saphenous vein. At

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this time the œdema of the right foot had subsided completely. The condition of the left limb was diagnosed as acute lymphangitis. The swelling of the left limb subsided in three days' time, and the temperature returned to normal. The wound in the right limb healed soundly, and the only legacy of the aneurysm was an indurated mass in Scarpa's triangle. The patient was not permitted to walk for three weeks. He left hospital twenty days after operation, with his wound healed and completely relieved of his symptoms (*Fig 140*)



*Fig 140*—Case 6 After operation for aneurysm of the femoral artery

and leg. Although the patient was old and feeble, the site of the aneurysm left no alternative but a disarticulation through the hip-joint (*Fig 141*)

**AT OPERATION**—Under general anaesthesia at 5 p.m., the right common femoral vessels were exposed and ligatured below Poupart's ligament. The walls of the artery were extensively calcified, and the artery was twice



*Fig 141*—Case 7 Photograph of the thigh after disarticulation through the hip-joint, showing the large aneurysmal sac

## Case 7—Aneurysm of the superficial femoral artery causing gangrene of the leg

**HISTORY**—O. B., aged 75 years, male, Mohammedan Indian trader, was admitted to the General Hospital on Sept 14, 1944, on account of gangrene of the right foot and leg. Seven months previously the patient had noted a lump in the right thigh which had gradually increased in size. He had sought advice previously, and had been told that it was necessary to amputate his limb on account of the lump, which was considered to be a tumour. Five days previously the foot had become green and dry and this had spread up the leg. No history of diabetes.

**ON EXAMINATION**—The patient was seen to have dry gangrene of the right foot and leg, with a line of demarcation a hand's breadth below the knee. There was a large lump in the thigh bulging on its anterior and inner aspects, extending from four fingers' breadth below the groin to a hand's breadth above the knee-joint. The swelling did not pulsate. There was some œdema of the tissues overlying the tumour. The common and superficial femoral arteries were felt passing from below Poupart's ligament up to the upper pole of the swelling. The walls of these arteries were calcified. The brachial and radial arteries were also extensively calcified, the calcified plaques being irregularly disposed rather than in annular rings. A small incision was made into the swelling of the thigh and blood spurted through the wound. The bleeding was arrested by means of a tight bandage placed over the incision. It was apparent that the gangrene of the foot and leg was the result of a large aneurysm of the superficial femoral artery, and the rigid atheromatous vessel walls. An immediate operation was imperative in view of the incision that had been made into the aneurysm, and the gangrene of the foot

the normal diameter. The limb was disarticulated through the hip-joint using an anterior racquet incision. **PROGRESS**—The old man stood the operation surprisingly well and was given half a pint of blood to counteract shock. His progress was satisfactory except for the fact that he was incontinent after operation, wetting the bed whenever the bladder became moderately full. On the fourth day he was refusing to take his food and appeared apathetic. There were now signs of consolidation of both bases of the lungs and the patient died on the ninth post-operative day.

This case is not one of a traumatic aneurysm, but it has been included on account of its special features

## Case 8—Traumatic aneurysm of radial artery

**HISTORY**—G. H. A. P., male, Sinhalese, aged 22 years, was admitted to the General Hospital, Colombo, on account of a lump in the left forearm of six months' duration. He had injured his forearm seven months previously, while cutting down a branch of plantains. The wound had bled profusely. The wound had been firmly bandaged and it had healed in seven days' time. A month later a lump was noted at the site of the scar and this had slowly got larger. There had been numbness in the thumb and the index and middle fingers for some hours, every two or three days.

**ON EXAMINATION**—There was a lump 2 in. in diameter in the front of the left forearm and in the line of the radial artery 1 in. above the palm (*Fig 142*). There was a scar  $\frac{1}{2}$  in. long just below the lump. The lump had an expansile pulsation synchronous with the pulse. This pulsation could be arrested by pressure on the



radial artery above the lump. The lump could be moved from side to side, but not from above downwards. There was a systolic murmur over the lump. There was no loss of sensation to pin-prick or cotton-wool over the forearm or hand. It is clear that this patient had sustained a traumatic aneurysm of the radial artery.

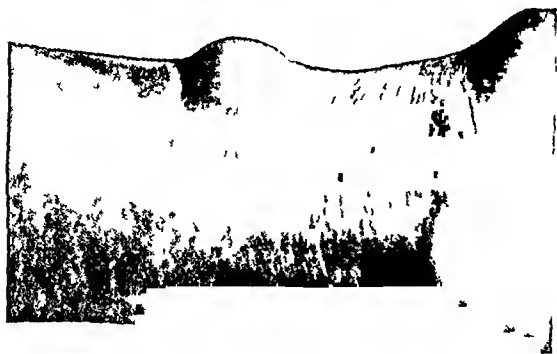


FIG 142—Case 8. Aneurysm of the radial artery.

**AT OPERATION**—On Feb 26, 1943, under general anaesthesia, a tourniquet was placed round the arm and a vertical incision made over the lump and the lump exposed. The radial artery entered above and emerged below it. The aneurysm was opened. It contained red blood-clot inside a thick sac. The arterial wall was reduced to a shallow groove in the floor of the sac. As the artery was considered irreparable, it was ligatured above and below the aneurysm and the sac excised. The wound was sutured.

The patient made an uneventful recovery from the operation and left hospital on March 3. There was no alteration in the warmth of the hand as a result of the ligature, and the only abnormality noted was the absence of the radial pulse.

### SUMMARY

Eight cases of aneurysm are described. In 4 cases the aneurysm was traumatic and saccular, and the arteries distal to the aneurysm exhibited almost normal pulsation. In these cases Matas' operation of reconstructive endo-aneurysmorrhaphy proved thoroughly practicable, the patient being cured by the operation.

In 3 cases the aneurysm was traumatic and fusiform. The arteries distal to the aneurysm showed no pulsation. Matas' obliterative endo-aneurysmorrhaphy served, however, to cure these patients of their aneurysms. In 1 case, which unfortunately proved fatal, the aneurysm was due to the rupture of an arteriosclerotic calcified vessel. In this case the aneurysm had caused gangrene of the foot, which necessitated a disarticulation through the hip-joint.

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## SOME OBSERVATIONS ON CARCINOMA OF THE PROSTATE TREATED WITH OESTROGENS—AS DEMONSTRATED BY SERIAL BIOPSIES

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THE employment of oestrogen therapy for carcinoma of the prostate appears in many cases to offer opportunities of symptomatic relief hitherto unobtainable by other methods. In some instances it is possible to detect a coincident regressive change in the size and consistency of the prostate gland, and also in those metastases which are accessible to palpation or radiography. However, in assessing such alterations in the prostate itself, or in lymph-gland and skin nodule metastases, much may depend on the judgement and veracity of the observer, while the comparative study of bone metastases may be confused through a failure to adopt a standardized radiographic technique. It has seemed to us that a method of treatment offering such promising clinical results would be established on a still firmer basis if visible regressive changes could be demonstrated in the microscopical structure of the organs concerned. Cytological changes in this direction have been recorded during the first two months of treatment (Schenken, Burns, and Kahle, 1942), but experience of the clinical course suggests that a more extended survey is desirable. We have, therefore, carried out repeated prostatic biopsies by the perurethral route in a small number of cases

receiving oestrogens over periods ranging from six months to two-and-a-half years. The correlation of our microscopical findings with the clinical and biochemical records of the cases forms the basis of this paper.

It will be recognized that the cases from which our material has been obtained represent only a small proportion of those receiving oestrogens, since individual circumstances frequently render repeated interference neither opportune nor justifiable.

In this connexion it may be well to refer to the different types of the disease in so far as they affect the opportunities for the performance of serial biopsies. Disregarding the cellular structure of the neoplasm, it seems convenient to distinguish two forms, differentiated by the site of origin of the growth and the previous condition of the gland in which it occurs. In the more common form the growth tends to arise in atrophic tissue in the posterior lobe of an otherwise normal gland (Moore, 1935). Giving rise to few symptoms at the outset, it is seldom detected before extension has occurred, thus rendering the chances of successful radical extirpation remote. Indeed, according to Thompson

(1942), in 95 per cent of patients the disease has spread beyond the confines of the prostate gland by the time they come under observation. In contrast, the rarer form of the disease develops secondarily in a gland showing benign hypertrophic changes, and may often remain latent until discovered on routine microscopy of the enucleated prostate. This form is referred to by Riches (1944) as affecting older men and being less lethal in character, but it seems possible that the lowered pathogenicity may in some cases be accounted for by an assumption of complete eradication consequent on the enucleation. Its infrequency is apparent from figures given and quoted by McGavin (1938), and our own records show an incidence of 2 per cent in the 'adenomatous' glands.

In view of the foregoing it is clear that it is the first form of the disease which lends itself particularly to study, since it is both more common and, at the time of its detection, has usually extended to a portion of the gland readily approached by endoscopic methods. Our material has been obtained solely from cases falling into this category.

It may be well to reiterate that even in this class many cases are unsuitable for repeated examination, since their clinical condition may be either too bad or too good to warrant interference. A number of patients, particularly among the poorer classes, are still first seen when almost moribund from chronic retention and uræmia. In such cases we feel that any preference for perurethral methods of relieving the urinary obstruction should be subordinated to the performance of temporary suprapubic drainage by the Riches technique (1943). It has been our experience that not all of these advanced cases are able to derive full benefit from oestrogens on account of irretrievable renal damage (Fergusson, 1944), and in view of their rapid decline the chance of securing serial material is not presented. On the other hand, in earlier and more favourable cases showing a satisfactory clinical response to oestrogens, the clearance of urinary infection and diminution of residual urine may also obviate the need for prostatic resection.

Between these extremes patients are encountered in whom, after an initial resection and continued treatment with oestrogens, a milder degree of retention, frequency, or dysuria persists. It is in such cases, where, despite a general systemic improvement, some slight urinary symptoms remain, that we have considered further resection justifiable.

Having indicated some of the limitations imposed upon an investigation of this character we now turn to the method by which we have attempted to correlate the prostatic microscopy with the course of the disease. This has entailed a careful survey of the clinical, biochemical, and radiographic records of the appropriate cases, together with a consideration of the oestrogen dosage and any adjuvant methods of treatment. The manner in which the relevant data were recorded is briefly set forth below.

**Clinical Findings**—A comprehensive note was made of the history and clinical state, with particular attention to the size and consistency of the prostate gland, the degree of urinary obstruction and infection, and the position and character of metastases.

Similar observations were made on frequent occasions and the patient subsequently examined at monthly intervals in the Out-patient Department. All findings were recorded on a special chart designed to facilitate comparison (Fergusson).

**Biochemical Tests**—Routine tests for renal function and urinary infection were performed at regular intervals in all cases and gave some indication of the degree of urinary obstruction.

Of more direct importance were the repeated estimations of the serum acid phosphatase upon which the dosage of oestrogen was largely based. These were carried out weekly at the commencement of treatment and later at longer intervals, and have seemed to us a valuable indication of the progress of the disease.

**Radiographic Examination**—Anteroposterior views of the lumbar spine, pelvis, and upper ends of the femora were taken before commencing treatment and at two-monthly intervals thereafter. In some cases, where indicated, other regions such as the chest, skull, or humeri were included. An endeavour was made to maintain a constant technique with regard to position, exposure, and kilovoltage for each individual so as to simplify the comparison of metastatic deposits.

Occasional use was made of intravenous pyelography as an indication of the amount of residual urine where we did not wish to influence the course of the urinary symptoms by catheterization.

## **Treatment**

**Specific**—Of the 5 cases here described 4 were treated with stilboestrol and 1 with dienoestrol. In general, we awaited the confirmation of the diagnosis by all available methods—palpation of the prostate, serum acid phosphatase estimation, radiographic evidence of metastases, and biopsy—before commencing treatment. However, in cases first observed with urinary retention oestrogen therapy was commenced on a provisional diagnosis during the stage of decompression, and biopsy performed within a few days. This seemed to us to give the maximum opportunity of restoring natural micturition and avoiding suprapubic drainage.

The dosages employed differed according to the clinical and biochemical findings, but usually initial doses of about 5 mg of stilboestrol or 2 mg of dienoestrol were prescribed twice a day. The amount was reduced as soon as a satisfactory response was obtained, and maintenance doses of about 2 mg of stilboestrol or 1.0 to 1.5 mg of dienoestrol twice daily continued.

**Palliative**—Urinary infection and symptoms due to metastases received uniform palliative treatment on standard lines when necessary.

**Operative**—Perurethral resection was carried out either before or shortly after the commencement of oestrogen therapy, and again on subsequent occasions during the continuation of treatment.

At the initial resection the aim was threefold—to remove obstructing tissue, to confirm the diagnosis by microscopy, and to obtain sufficient material to diminish any error in the microscopical comparison with tissue resected subsequently. The fragments were removed with the Gershom-Thompson (cold punch) instrument and the material to be examined taken from a similar site on each occasion, namely,

the posterior quadrant of the prostatic urethra immediately above the verumontanum. The danger of accidental selection of fragments, which by their anatomical structure might influence the distribution and extension of the growth, was thus somewhat diminished. From six to eight fragments measuring approximately  $1 \times 0.5 \times 0.5$  cm, and of total moist weight 1.0–1.2 g were taken for examination. The possibility of a traumatic reaction resulting from the initial resection and affecting the microscopy of tissue obtained on a later occasion occurred to us, particularly if excessive diathermy cauterization was employed. For this reason special effort was made to avoid using diathermy for hæmorrhage whenever possible after completing the resection, and reliance was placed mainly on the Foley's catheter and regular irrigation. Using similar restraint, a small number of serial biopsies in cases of simple prostatic hypertrophy was carried out and the traumatic reaction found to be negligible.

Proceeding on these lines a degree of uniformity was achieved which we hoped might be reflected in the microscopical findings. The material obtained consisted of prostatic tissue fragments taken on two or more occasions from five patients belonging to the clinical group to which we have referred. In all the patients our records showed general improvement from the clinical and biochemical standpoints following the employment of oestrogens.

### MORBID HISTOLOGY

A preliminary study of sections of the prostatic tissue obtained at the initial and subsequent resections showed both quantitative and qualitative changes in the neoplastic areas. In addition to an apparent reduction in the number of tumour units in the later sections certain cellular changes were noticeable, among which a diminution in the size of the nuclei was prominent. These findings suggested that a detailed comparison could best be made in two directions, first, by a quantitative estimate of the number of tumour units in fields of standard size, and secondly, by a descriptive record of the cellular changes, substantiated by measurements of the nuclear diameters. It was clear, however, that any quantitative comparison of the tumour units would be influenced by vagaries of anatomical structure and by the extent and cellular differentiation of the growth. The former difficulties could be minimized by the examination of extensive areas of tissue, and for this reason we made a large number of serial sections of all representative fragments. The impracticability of counting tumour units in the one case of undifferentiated carcinoma, however, proved insuperable and forced us to adopt a descriptive comparison in this instance.

For comparative purposes the number of tumour units in microscopical fields amounting to 10 sq mm was counted by impartial observers, and an average taken corresponding to the number of units per sq mm. Apart from a consistent decrease in

the later sections, the majority of units also showed considerable diminution in size. The effect produced can perhaps be best appreciated by reference to Figs 143–147, which show representative fields taken from sections of the initial and subsequent biopsy material in the five cases. The general trend illustrated appears to be a regressive change from a more cellular type of growth to a scirrhous form.

The numerical estimates of the tumour units, correlated with the interval between the resections

Table I

CASE	NUMBER OF RESECTIONS	INTERVAL BETWEEN RESECTIONS	AMOUNT OF OESTROGEN RECEIVED	TUMOUR UNITS PER SQUARE MILLIMETRE
1	1	Initial 10 days 17 months	Stilbæstrol 100 mg 4380 mg	66
	2			—
	3			23
2	1	Initial	Stilbæstrol	Uncountable (undifferentiated carcinoma)
	2	5 months	1980 mg	See Fig 144
	3	16 months	4128 mg	
3	1	Initial 10 months	Stilbæstrol 1792 mg	50.1
	2			8.1
4	1	Initial 30 months	Stilbæstrol 3548 mg	78.9
	2			28.0
5	2	Initial 6 months	Dienæstrol 500 mg	150
	1			30

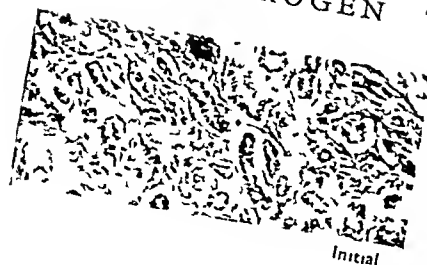
and the amount of oestrogen received, are given in Table I.

In addition to a numerical comparison of the units of growth we hoped to be able to confirm and supplement the findings of Schenken, Burns, and Kahle (1942) with regard to qualitative microscopical changes. For this purpose fresh sections were prepared from the biopsy tissues and stained simultaneously. A comparison again revealed well-marked changes in the later sections, showing a tendency towards diminution in size of the cell nuclei, with concentration of chromatin and pyknosis. In the sections made from the initial biopsy material, the majority of tumour cells had large vesicular nuclei, although a number of pyknotic nuclei were also present. In sections made from later material pyknotic nuclei were found almost exclusively in four of the cases, and in many instances these appeared to be free, the retaining cellular body having disintegrated. In two of the cases progressive vacuolation of the cells was also observed.

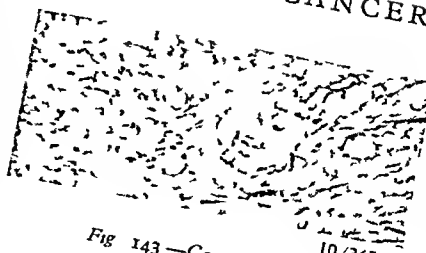
To supplement the description of the cytological changes we recorded measurements of the nuclear diameters in all the cases. This procedure, again carried out by impartial observers, was tedious and involved the measurement of between 1000 and 1500 nuclei in each case examined. A comparison of the average diameters of the nuclei in the cases examined confirmed our original visual impression, and the results are given in Table II. This shows a notable decrease in size in three of the cases, while in the remaining two (Cases 3 and 4) the change is slight.

In order to emphasize the general nature of the diminution in nuclear size in these cases we have reproduced our results in graphic form (Figs 148–152).

# ESTROGEN THERAPY IN CANCER OF PROSTATE



Initial

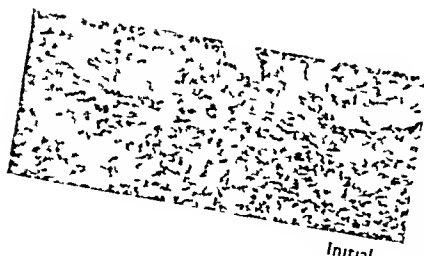


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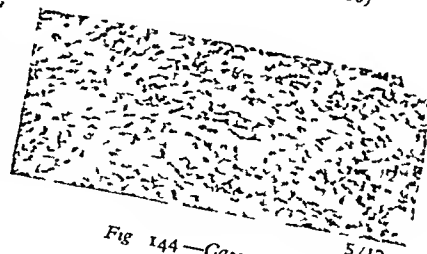
Fig 143—Case 1 (× 16)



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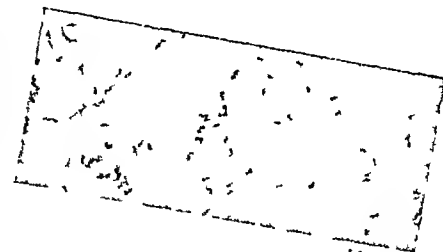


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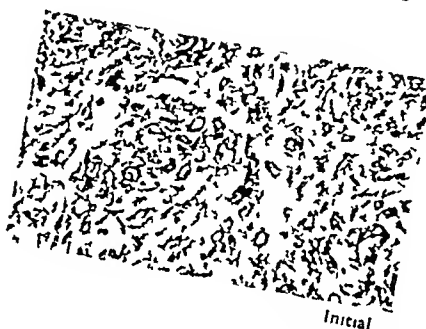


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Fig 144—Case 2 (× 60)



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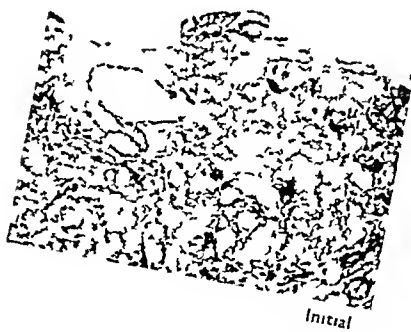


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Fig 145—Case 3 (× 60)

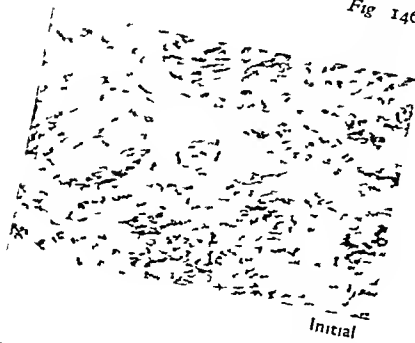


Initial



30/12

Fig 146—Case 4 (× 44)



Initial



6/12

Fig 147—Case 5 (× 60)

Figs 143-147—Microphotographs of representative sections taken from serial biopsy material in the five cases, showing diminution in number and size of the tumour units. The intervals between the biopsies are indicated beneath each section.

Table II

CASE	INTERVAL BETWEEN RESECTIONS	AMOUNT OF ŒSTROGEN RECEIVED	AVERAGE DIAMETER OF NUCLEI IN MICRONS
1	Initial 10 days 17 months	Stilbœstrol 100 mg 4380 mg	7.75 4.82 4.65
2	Initial 5 months 16 months	Stilbœstrol 1980 mg 4128 mg	9.75 — 5.95
3	Initial 10 months	Stilbœstrol 1792 mg	7.32 6.11
4	Initial 30 months	Stilbœstrol 3548 mg	7.2 6.9
5	Initial 6 months	Dienœstrol 500 mg	6.28 4.23

In brief, the histological findings were that the later sections showed a notable reduction in tumour units in all cases, with a coincident decrease in size

nocturnal 1½-hourly) had been troublesome and there had been slight scalding on urination. Pains in the outer and posterior portions of the thighs had recently become aggravated.

He was found to have a distended bladder, and rectal examination revealed a hard, nodular prostate with fixation to the surrounding structures. A considerable degree of anæmia was present and it was evident that he had lost weight.

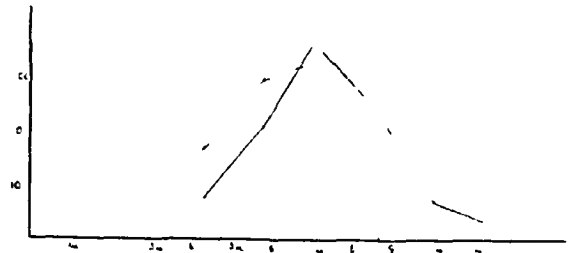


Fig 150—Case 3

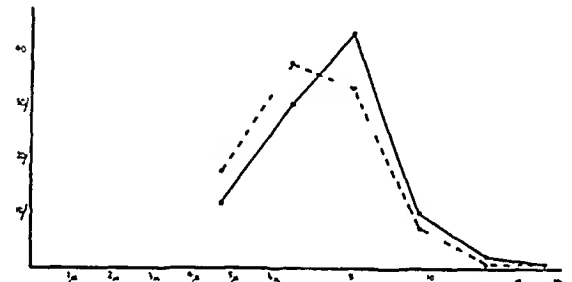


Fig 151—Case 4

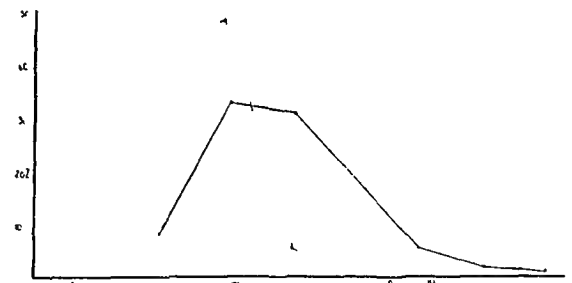


Fig 152—Case 5

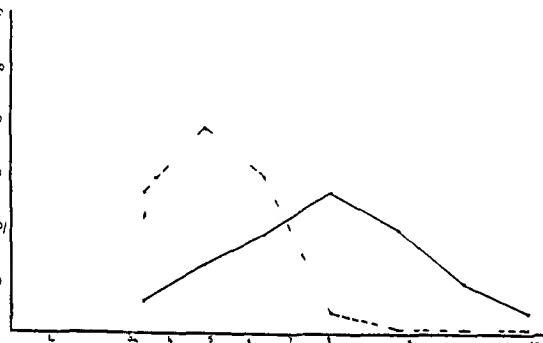


Fig 148—Case 1

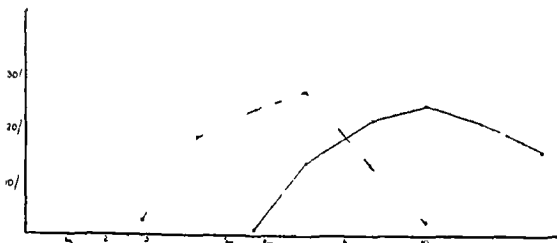


Fig 149—Case 2

FIGS 148-152—Graphic records showing the change in the nuclear diameters. The percentage of nuclei of certain size is plotted against the nuclear diameters. The continuous line represents the initial state, and the broken lines the later findings. A shift from right to left indicates the reduction in average nuclear diameter.

in three. Retrograde cytological changes were apparent in all cases, and in three instances there was a statistically significant diminution in the average nuclear diameter.

### CASE REPORTS

Brief histories of the cases are appended with the inclusion of the relevant biochemical and radiographic records.

#### Case 1—

HISTORY—A patient aged 75 complained of increasing difficulty of micturition for one year culminating in inability to pass water. Frequency (diurnal 1-hourly,

Biochemical examination showed a blood-urea content of 89 mg per 100 c.c., and a serum acid phosphatase value of 3.5 units per 100 c.c.

Radiographs indicated the presence of metastases in the pelvis and lumbar spine, and also in the neck of the left femur.

TREATMENT—The retention was relieved by slow decompression by indwelling catheter, the urine containing a small amount of pus and growing *B. coli* on culture. At the same time treatment with stilbœstrol (5 mg twice a day) was instituted. Following withdrawal of the catheter he was still only able to pass urine with difficulty. Perurethral resection of prostatic tissue was first carried out four days after the commencement of œstrogen therapy and again ten days later.

**PROGRESS**—His subsequent progress was satisfactory, the residual urine diminishing to less than an ounce and his frequency abating to twice nightly and two-hourly during the day. He made no further complaint of pain, and increased his weight by over a stone in six months. The blood-urea content fell to 33 mg per 100 c.c., and the average serum acid phosphatase value on subsequent estimation was 1.5 units per c.c. The haemoglobin rose from 59 per cent to 95 per cent.

Oestrogen dosage varied between 6 mg and 15 mg of stilboestrol daily, until after sixteen months it was thought desirable to reduce it to 4 mg a day on account of increasing headaches and dizziness. Following the reduction he experienced slight difficulty of micturition, and the third perurethral resection was performed a month later. The serum acid phosphatase value at this time was 1.4 units per c.c. He has since continued in good health on a daily dose of 4 mg of stilboestrol, and has now received treatment for over two years. The prostate, although smaller and softer, remains recognizably 'malignant' on palpation. Radiographic records show little change in the character and distribution of the bony metastases.

**Side Effects**—The sensation of dizziness, which has been noted in other cases receiving oestrogens, appeared to be closely related to the taking of stilboestrol. The patient volunteered the information that he had found relief on omitting to take the tablets for short periods, and remained almost free from trouble after the reduction in dosage. Some rise of blood-pressure took place prior to the onset of the disturbance, and this has since continued at a high level.

Slight tenderness of the breasts occurred after six months' treatment, but has now disappeared. The testes have become shrunken and sexual activity much reduced.

#### Case 2—

**HISTORY**—A patient aged 72 was admitted to hospital suffering from retention of urine. He had suffered from extreme frequency of micturition for some months, having to rise from bed as often as twelve times during the night. During the two months prior to his admission he had been afflicted with agonizing pains in the outer side of the thighs. He stated that he had recently lost weight.

On examination he was found to have a distended bladder and his prostate felt extremely hard and nodular, with extension of the induration into the surrounding tissues on the left side.

Biochemical examination showed a blood-urea content of 42 mg per 100 c.c., and a serum acid phosphatase value of 9.5 units per c.c.

Radiographs indicated the presence of scattered secondary deposits in the pelvis, and also in the ribs and clavicles.

**TREATMENT**—The retention was relieved by slow decompression by indwelling catheter, the urine containing a small amount of pus and growing *B. coli* on culture.

Treatment with stilboestrol (5 mg twice a day) was commenced at the same time. On withdrawal of the catheter four days later he remained unable to pass urine, and perurethral resection was carried out.

**PROGRESS**—One month later his general condition had much improved, and while able to micturate with ease, he was able to forego this satisfaction for periods of up to three hours at a time. His residual urine declined to between  $\frac{1}{2}$  oz and 3 oz, and became sterile on culture. The pains in his thighs diminished in intensity and he began to put on weight.

The serum acid phosphatase value fell to 2.1 units per c.c., and subsequently remained on the average at 2.4 units.

Five months after the commencement of treatment he began to experience further difficulty in passing urine, and the second perurethral resection was performed.

Following this he remained in good health on an average dose of 6 mg of stilboestrol daily, and put on 8 lb in weight.

The third perurethral resection was carried out sixteen months after the commencement of treatment on account of an increase in the residual urine.

At the present time, after two years' treatment with stilboestrol, he remains free from pain and complains of no urinary disturbance apart from having to micturate three times during the night.

Palpation of the prostate shows this to have become very small, but the degree of induration is still suggestive of carcinoma. Radiographic records show no change in the character of the metastases.

**Side Effects**—Considerable mammary enlargement and tenderness took place after the first month of treatment, and more recently a very marked dark-brown pigmentation has occurred over a circular area, about  $2\frac{1}{2}$  in in diameter, surrounding the nipples.

The testes have become very small and sexual activity is absent.

#### Case 3—

**HISTORY**—A patient aged 61 attended hospital on account of progressive difficulty in passing water for nearly a year and recent haematuria. Occasional pain in the thighs had been experienced. His general condition was comparatively good, but on rectal examination his prostate was found to be indurated and nodular to an extent suggesting malignancy.

Biochemical examination showed a blood-urea content of 47 mg per 100 c.c., and a serum acid phosphatase value of 15.5 units per c.c.

Radiographs indicated the presence of both osteoplastic and osteolytic deposits in the pelvis.

**TREATMENT**—At cystoscopy he was found to have 10 oz of residual urine, which contained a little pus and grew the *B. coli* on culture. Perurethral resection of the obstructing prostatic tissue was carried out, and microscopy of the fragments removed confirmed the diagnosis of carcinoma.

Treatment with stilboestrol (3 mg daily) was instituted.

**PROGRESS**—Following this he was able to comment that he was passing water more easily than for years, and his residual urine fell to 2 oz and became sterile. No further pain was experienced in the thighs. The blood-urea content remained between 40 mg and 50 mg per 100 c.c., but the serum acid phosphatase value fell to 1.2 units per c.c., and remained at this average level on subsequent estimation.

Oestrogen dosage varied between 0.5 mg and 4 mg of stilboestrol daily.

His weight remained constant, and apart from occasional dizziness he remained free from symptoms until ten months later, when the second perurethral resection was carried out on account of the return of slight dysuria and an increase in the residual urine. Since this time his progress has been maintained and at present, after fifteen months of oestrogen therapy, his general condition shows marked improvement. The prostate is now almost impalpable, and though remaining firm would not arouse suspicion as to its malignant nature.

Radiographs show no alteration in the character and distribution of the bony metastases.

**Side Effects**—Occasional attacks of dizziness were experienced for some months during treatment and a slight rise in blood-pressure took place.

The breasts, which showed considerable enlargement and tenderness, now show some regression.

After three months' treatment he noticed a smaller ejaculate and shrinkage of the testes. Sexual activity disappeared completely. Indeed, after an alleged incident near his place of employment he was vigorously able to defend himself against imputations of peculiar behaviour.

## Case 4—

**HISTORY**—A patient aged 70 was admitted to hospital with retention of urine following increasing difficulty in passing water for nearly a year. Frequency of micturition had been troublesome, and he had experienced pain in the lumbar region and inner part of the thighs which almost prevented him from walking.

His bladder was distended, and the prostate, although relatively small, was hard and nodular. A considerable degree of anæmia was present and œdema of the ankles was marked.

Biochemical examination showed a blood-urea content of 86 mg per 100 c.c., and a serum acid phosphatase value of 30.0 units per c.c.

Radiographs showed the presence of metastases in the pelvis.

**TREATMENT**—His retention was relieved by slow decompression by an indwelling catheter, the urine containing a small amount of pus and growing *B. coli* on culture.

of an increased difficulty in initiating micturition. He has since remained well and has now been under treatment for three years. The prostate is very small and hardly palpable, though still of firm consistency.

Radiographs show slightly increased sclerosis in some of the bony metastases, with corresponding hardening of outline.

**Side Effects**—Tender enlargement of the breasts was noted after a month's treatment. Shrinkage of the testes and pigmentation of the perineal raphe also occurred.

## Case 5—

**HISTORY**—A patient aged 60 complained of general asthenia and pain in the right hip for several months. In addition, he had noticed increasing frequency and scalding dysuria, and marked loss of weight.

His general condition was poor and he was profoundly anæmic. The prostate was hard and nodular, with fixation to the surrounding structures.

Table III

CASE	INTERVAL BETWEEN RESECTIONS	TUMOUR UNITS PER SQ. MM.	AVERAGE DIAMETER OF NUCLEI IN MICRONS	AMOUNT OF ŒSTROGEN RECEIVED	CLINICAL COURSE	SERUM ACID PHOSPHATASE	RADIOGRAPHIC FINDINGS
1	Initial 10 days 17 months	66 — 23	7.75 4.82 4.65	Stilbœstrol 100 mg 4380 mg	General improvement, loss of pain, gain (1 st.) in weight, hæmoglobin 59–95 per cent, prostate became smaller and softer.	Initial 3.5 units, subsequent average 1.5 units	No appreciable change
2	Initial 5 months 16 months	Uncountable (undifferentiated carcinoma) —	9.75 — 5.95	Stilbœstrol 1980 mg 4128 mg	General improvement, loss of pain, gain (8 lb.) in weight, prostate became smaller but still firm.	Initial 9.5 units, subsequent average 2.4 units	No appreciable change
3	Initial 10 months	50.1 8.1	7.32 6.11	Stilbœstrol 1792 mg	General improvement, loss of pain, weight constant, prostate became very small but firm.	Initial 15.5 units, subsequent average 1.2 units	No appreciable change
4	Initial 30 months	78.9 28.0	7.2 6.9	Stilbœstrol 3548 mg	General improvement, diminution of pain, increase of weight, prostate became very small but firm.	Initial 30.0 units, subsequent average 1.2 units	Some increased sclerosis and hardening of outline of deposits in later films.
5	Initial 6 months	150 30	6.28 4.23	Dienœstrol 500 mg	General improvement, loss of pain, gain (2 st.) in weight, hæmoglobin 44–90 per cent, prostate became smaller and softer.	Initial 7.5 units, subsequent average 2.8 units	Increased sclerosis of deposits in later films.

Following withdrawal of the catheter he was able to pass urine fairly well, but his residual urine still amounted to nearly half a pint. Perurethral resection of the obstructing tissue was carried out, and thereafter he made good progress.

**PROGRESS**—Owing to unfamiliarity with the effect of œstrogens at this time he received only sporadic courses of treatment with stilbœstrol during the next few months, and was later readmitted with a further attack of urinary retention which was relieved by catheterization.

Thereafter he was maintained on doses varying between 4 mg and 15 mg of stilbœstrol daily, controlled by the serum acid phosphatase value. This value fell to an average of 1.2 units per c.c. on subsequent estimations, and the blood-urea content to 36 mg per 100 c.c.

His later progress was satisfactory and he began to put on weight. Although he still complained of occasional pain in the thighs, this no longer interfered with his walking.

A second perurethral resection was carried out thirty months after the commencement of treatment on account

Biochemical examination showed a blood-urea content of 48 mg per 100 c.c., a serum acid phosphatase value of 7.5 units per c.c., and a hæmoglobin percentage of 44.

Radiographs showed the presence of metastases in the pelvis, lumbar spine, and necks of both femora.

**TREATMENT**—A perurethral biopsy of the prostate was performed to confirm the diagnosis and œstrogen therapy commenced, using dienœstrol in doses of 3 mg a day.

**PROGRESS**—Rapid improvement occurred, accompanied by loss of pain and relief of the urinary symptoms. His hæmoglobin rose from 44 per cent to 90 per cent, and he put on 2 st. in weight in six months.

The blood-urea content fell to 35 mg per 100 c.c., and the serum acid phosphatase value declined to an average of 2.8 units per c.c.

The dosage of dienœstrol varied between 3 mg and 5 mg daily.

A modified perurethral resection was carried out after six months on account of some persistence of nocturnal frequency, but the amount of residual urine was less than 2 oz.



# ESTROGEN THERAPY IN CANCER OF PROSTATE

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His recent progress has been satisfactory, and after one year's treatment he remains free from symptoms. The prostate has become very small and though softer is still recognizably malignant.

Radiographs show increased sclerosis in the bony metastases.

**Side Effects**—Occasional dizziness was complained of at the onset of treatment, but this may have been caused by the anaemia. Very slight tenderness of the nipples was noted during treatment, but no palpable enlargement of the breasts.

Sexual activity has declined and the testes have diminished to half their normal size.

**Table III** gives a comprehensive review of the histological findings and the clinical, biochemical, and radiographic records of the five cases.

**Comment on the Cases**—All the above cases have been subjected to perurethral resection of obstructing prostatic tissue in addition to receiving oestrogen therapy. The difficulty in ascribing their improvement to either or both methods of treatment is immediately evident. It is clear that the operative measures must have a direct, though possibly temporary, effect on the urological condition, and to avoid prejudice, we have omitted any record of the amelioration of urinary obstruction in less than a year. As to how far the general improvement may be a reflection of relieved urinary obstruction is less certain, and we have therefore tabulated this as a fairer index of the oestrogenic response.

## DISCUSSION

The treatment of prostatic carcinoma with oestrogens has been largely developed from the observations of Huggins and his associates (1941), showing that normally active prostatic epithelium

series, however, we know of no instance in which such a clinical 'cure' has been accompanied by radiographic evidence of the complete dissolution of bony metastases.

We also recognize that our histological studies may not be wholly representative in that they take no account of a small number of cases in which no apparent clinical response to oestrogens takes place. In such instances the persistence of an elevated serum acid phosphatase value, despite massive doses of oestrogens, suggests that prostatic epithelial activity remains unchecked and the histological picture correspondingly unaltered. Although not invariably raised, we have found the serum acid phosphatase value to be the most reliable criterion of reaction to oestrogen therapy, and depend on it in preference to the mammary changes, pigmentation, and other side effects. That it represents the general response of both primary and secondary deposits is suggested by the fact that, in a number of prostatic fragments which we examined, the phosphatase content bore no constant relation to the serum value. Further evidence of this production of acid phosphatase by metastatic deposits is furnished by the following case—

A patient aged 71 suffering from prostatic carcinoma was found to have metastases in the inguinal and axillary lymph-glands. Two adjacent glands of comparable size in the right axilla were particularly hard and discrete. One of these was removed at the commencement of treatment with dieneoestrol and the other three weeks later, by which time it had become appreciably smaller and softer. In the meantime, the serum acid phosphatase value had fallen from 6.2 to 0.8 units per

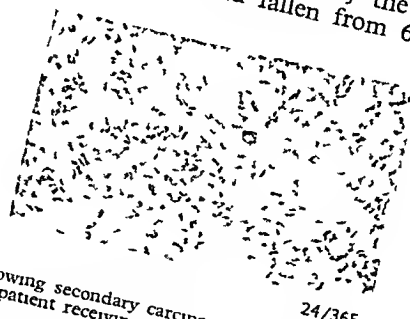
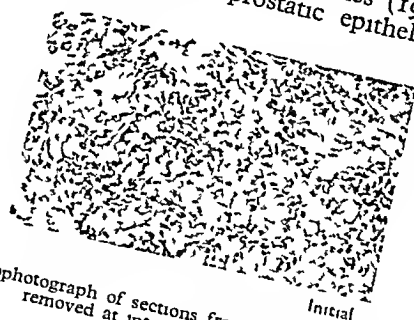


FIG 153—Microphotograph of sections from two axillary glands showing secondary carcinomatous invasion. The glands were removed at intervals of twenty-four days from a patient receiving dieneoestrol ( $\times 90$ )

could be made to atrophy by neutralizing the androgenic hormones. The investigations which we have described lead us to believe that the unrestrained epithelial activity of prostatic carcinoma may respond in a similar manner. Our cases are too few, however, to enable us to do more than suggest that regressive histological changes are a fairly constant accompaniment of oestrogen therapy. No conclusions can be drawn, as yet, as to the possibility of complete destruction of a developed carcinoma by means of oestrogens. It will be observed that in none of the cases has a complete disappearance of carcinomatous tissue been noted. This may be due to our method of selection, and it is conceivable that some patients who become dispossessed of all clinical evidence of the disease may attain such a favourable result. From our experience of cases outside the present

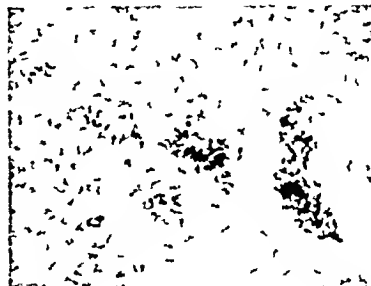
c c Both glands were fixed by similar methods, and the sections obtained stained simultaneously to show, on the one hand, the histological structure, and on the other, the acid phosphatase content. The comparative histology (Fig 153) closely resembled that previously found in prostatic tissue. The glandular structure in each case was replaced by neoplastic tissue to an almost corresponding extent, but whereas in the first gland the tumour units and their constituent cells were large, those in the second gland appeared smaller and pyknotic. Sections stained by the method advocated by Gomori (1941) showed the presence of acid phosphatase in both cases, but with a considerable reduction in the second gland. Whereas in the first gland every neoplastic cell appeared to elaborate the phosphatase, many areas of growth in the second gland failed to

show its presence, and even where found it seemed to stain to a lesser degree (*Fig 154*). In his survey of the distribution of acid phosphatase in the tissues Gomori states that normal lymph-glands contain

has been obtained. Carcinomatous prostatic tissue removed at intervals varying from six months to two-and-a-half years from five patients receiving oestrogens, has been examined histologically. Microscopical



Initial



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FIG 154—Microphotograph of sections taken from the two axillary glands depicted in *Fig 153*, and stained to show acid phosphatase ( $\times 90$ )

none, but that metastatic tissue from certain epithelial neoplasms, other than those of the prostate, may be positive.

Since we are unable to aver that both these glands were affected similarly by carcinoma in the first instance we make no claim as to the oestrogenic response in this case. We cite it merely to illustrate the production of acid phosphatase by metastases. Were it not for the probability that in carcinoma of the prostate such metastases only occur in conjunction with other unmistakable evidence of the disease, this method of phosphatase assay by glandular biopsy might prove of diagnostic significance in the differentiation from non-phosphatase-producing tumours.

### SUMMARY

An attempt has been made to correlate the histological findings in serial perurethral biopsies of carcinomatous prostatic tissue with the clinical improvement noted during prolonged oestrogen therapy.

Mention is made of the mode of selection of cases and attention drawn to certain features which may render repeated examination impracticable.

The importance of comprehensive clinical, biochemical, and radiographic records, as an index of the oestrogenic response, is stressed, and description given of the method by which the biopsy material

changes showing a diminution in number and size of the tumour units, together with cytological changes including a reduction in the nuclear diameter, were observed in the later material.

The value of acid serum phosphatase estimation in assessing the course of the disease is alluded to, and mention made of a case in which phosphatase was demonstrated in glandular metastases.

We are particularly indebted to Miss M. Smith for her assistance in carrying out the exhaustive measurements of the nuclear diameters and in the computation of the tumour units. We would also express our thanks to Mr J. Mayhew for his assistance in the preparation of the histological material, and to Miss H. Saxl, who has been responsible for the microphotography.

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## A HISTOLOGICAL STUDY OF A PREDEGENERATED NERVE AUTOGRAFT

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ENOUGH evidence has accumulated to show that autografts are the only type of nerve-graft which can be used in man with any hope of success. The successful results of autografting have almost without exception been cases where the gap in the nerve could be bridged by a graft of small calibre as in the facial or digital nerves (Duel, 1933; Bunnell and Boyes, 1939; Collier, 1940), or in the larger

nerve-trunks by a cable graft. Even under the most favourable conditions a cable graft will provide only a very indifferent pathway for the new nerve-fibres. Occasionally it may be possible to procure a graft comparable in diameter to the injured nerve. For instance, when a patient has suffered an amputation as well as an extensive nerve injury a nerve can be removed from the amputation stump,

or, if there are large gaps in two nerve-trunks, a segment from the less important nerve may be used to bridge the gap in the other (Seddon and Holmes, 1944)

In this case an experimental autograft was performed in a patient in which it was impossible to bridge a very large gap in an ulnar nerve. The graft was taken from the distal end of the damaged ulnar nerve and sutured to the central stump. Five and a half months later the graft was excised and examined histologically. This enabled us to study (1) The histological condition of an autograft predegenerated for a long period—in particular, its ability to survive without necrosis and to receive and conduct nerve-fibres, and (2) The regenerative capacity of the central stump after a similar long interval. The only other full histological account of an innervated human autograft is that of Seddon, Young, and Holmes (1942)

### CASE REPORT

**HISTORY**—J W, aged 27, was wounded on March 9, 1941, by a machine-gun bullet. He suffered an extensive wound of the soft tissues over the inner side of the right elbow-joint with comminution of the lower end of the humerus and upper ends of the radius and ulna, and a complete lesion of the ulnar nerve. Several days elapsed before he could be given definitive treatment, and the wound became heavily infected. It was not until one year later that the wound was soundly healed. On Oct 16, 1942, he was admitted to the Nerve Injury Unit at the Winwick Emergency Hospital. The elbow-joint was ankylosed in a position of 20° below the right angle. There was an extensive scar involving the skin and soft tissues over the inner side of the joint, and no evidence of any recovery of the ulnar nerve lesion. Exploration of the nerve was advised, although it seemed unlikely that a successful repair could be performed.

**FIRST OPERATION** (Nov 12, 1942), 613 days after injury—Under general anaesthesia an incision was made from the axilla to the lower third of the forearm.

#### *Condition of Nerve*—

**Central Stump** There was a large end bulb 8 cm above the elbow. From there the nerve gradually tapered until at a point 10 cm above the bulb it became of normal diameter. This portion of the nerve was distinctly firmer than usual, 10 cm of the central stump was resected.

**Histological examination** There are numerous bundles with well-preserved axons and myelin sheaths, but in a few of the bundles some of the nerve-fibres show swelling of the axons and fragmentation of the myelin sheath. The perineurium of the affected bundles is somewhat thickened. There is some oedema of the interfascicular connective tissue and the bundles are more widely spaced than in normal nerve.

**Peripheral Stump** The peripheral stump terminated in scar tissue 6 cm below the elbow-joint. It was necessary to resect about 3 cm of the central end of the peripheral stump to expose 'normal' nerve-bundles.

**Histological examination** Well-defined nerve-bundles separated by increased interfascicular connective tissue. The bundles themselves are shrunken and there is no evidence of axons or myelin sheaths.

**Grafting**—It was evident that suture of the nerve could not be performed even after anterior transposition, and a cable autograft was equally impossible. It was decided, therefore, to perform an experimental autograft. 7 cm of the distal end of the nerve were excised and sutured to the central stump with three fine linen thread sutures which were passed only through the sheath of the nerve. Owing to the difference in the diameter of the graft (3 mm) and the central stump

(6 mm), only about 25 per cent contact between the stump and the graft was obtained. The distal end of the graft was sutured to the intermuscular septum. There was little or no scarring of the soft tissues on which the graft lay.

**SECOND OPERATION** (April 29, 1943), 168 days after insertion of the graft—Under local anaesthesia an incision was made in the line of the graft. The graft was readily identified, a good junction had apparently been made between it and the central stump. There was a fusiform swelling at the suture line which was distinctly firmer than the nerve above. The graft itself appeared to be firmer than at the time of insertion, it was not unduly adherent to the surrounding tissues.

The graft was stimulated with a faradic current but no sensory response was obtained distal to a point 1 cm below the suture line.

The entire graft was excised together with a further 2 cm of nerve from the central stump and retained for histological examination.

Material taken out for histological examination was fixed in formol-saline, cut in blocks of 10–15 mm, and embedded in paraffin. Cross-sections were cut at 5 $\mu$ , 10 $\mu$ , and 20 $\mu$  from each block and stained by one of the following methods: haemalum and eosin, Mallory's triple stain, modified protargol, or a modified Weigert method. Finally, each block was sectioned longitudinally at 10 $\mu$  and sections were mounted in two series. Modified protargol method was used for one series and haemalum and eosin staining for the other.

**Central Stump** There is no epineurium. The interfascicular connective tissue is decidedly fibrous and there is no evidence of the loose connective tissue with occasional fat cells normally found in the larger human nerves. The perineurium is distinct and well developed. The sections show a sufficient number of healthy bundles to ensure regeneration (Fig 155). In most of the fascicles the majority of nerve-fibres are well myelinated with

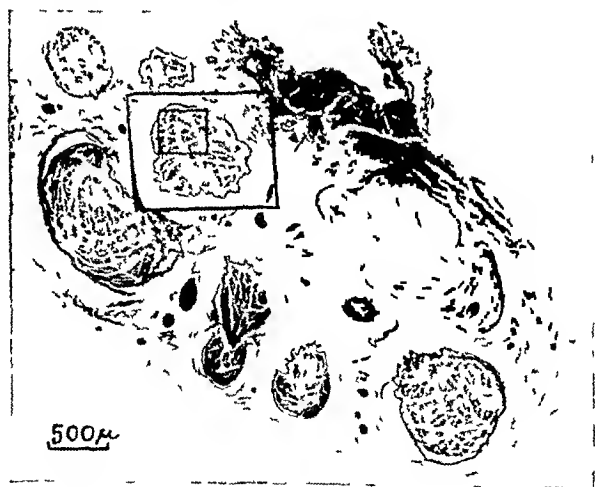


FIG 155—Central stump. Cross-section. Modified protargol method.

the normal proportion of non-myelinated fibres (Figs 156, 157). In longitudinal sections it can be seen that the majority of myelinated fibres lose their myelin sheath at about 2 mm from the suture line. This may mark the extent of retrograde degeneration after the resection of the neuroma of the central stump at the first operation. Above that limit the myelin sheath of the medullated fibres is normal. Inside the fascicles there is a slight degree of interfascicular collagenization under the perineurium and in the form of thickened endoneurial septa (Fig 158). No proliferation of Schwann cells can be seen and only a few macrophages. Numerous large blood-vessels are present in the interfascicular tissue,

but few capillaries. The fairly numerous peripheral hæmorrhagic areas can probably be attributed to handling at operation.

**Graft Junction.** There is good tissue junction. In the longitudinal silver-stained sections (Fig 159) the nerve-fibres can be traced from the central stump through the junction into the nerve-bundles of the graft. At the level of the junction there is much irregularity and criss-crossing of fibres and a large number of aberrant fibres.

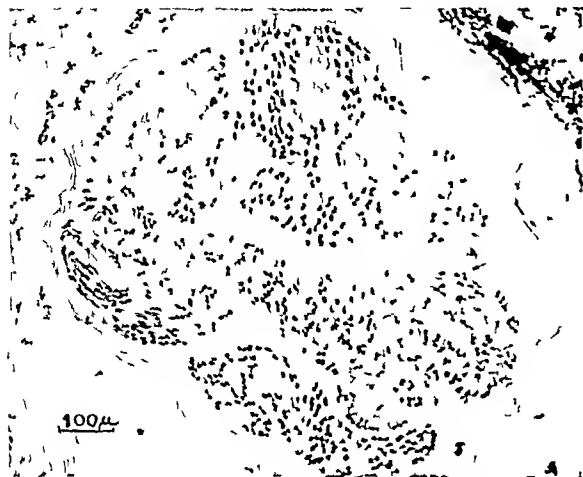


FIG 156—Central stump. Cross section of bundle indicated by large square in Fig 155. Modified Weigert staining.

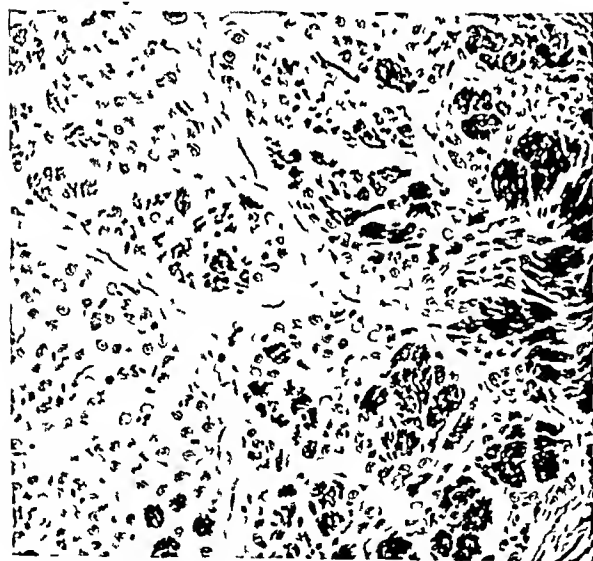


FIG 157—Central stump. Cross section representing area of small square of Fig 155. Clusters of non-myelinated fibres in right side of the field. Modified protargol method.

but no Perroncito spindles (Fig 160). Some medullated fibres can be followed almost to the suture line. The hæmalum and eosin and triple-stained sections show hæmorrhagic areas, a large amount of fibrous tissue, and Schwann nuclear proliferation. In the neighbourhood of the suture line there are round-cell infiltrations and occasional foreign-body giant cells.

**Graft Tissue.** Bundles of nerve-fibres can be followed throughout the whole length of the graft (Fig 161). The bundles are smaller and more numerous than in the central stump (Fig 162), which may in part be due to the fact that the graft represents a more peripheral portion.



FIG 158—Central stump. Cross section representing area of large square of Fig 155. Noticeable intrafascicular fibrosis. Modified protargol method.

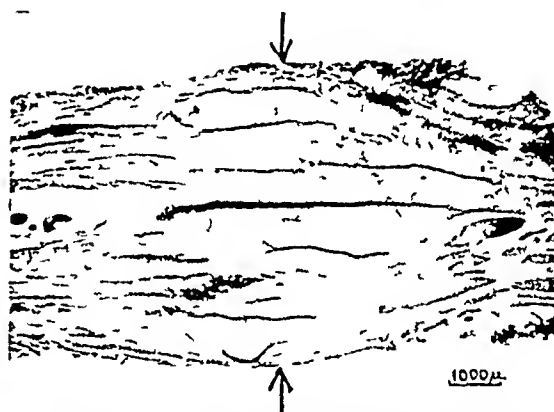


FIG 159—Junction of graft with central stump. Longitudinal section. Central stump left side, graft right side, arrows mark level of suture line. Modified protargol method.

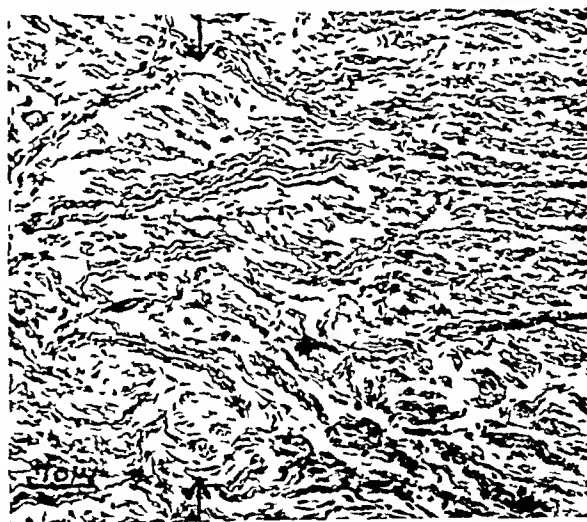


FIG 160—Junction of graft with central stump. Longitudinal section. Central stump left side, graft right side, arrows mark approximate level of suture line. Modified protargol method.

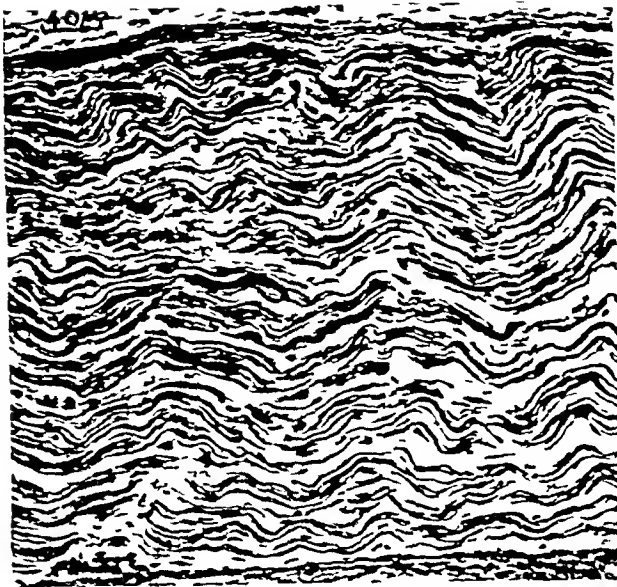


FIG 161—Graft Longitudinal section of bundle indicated in Fig 162 to show presence of nerve-fibres Modified protargol method

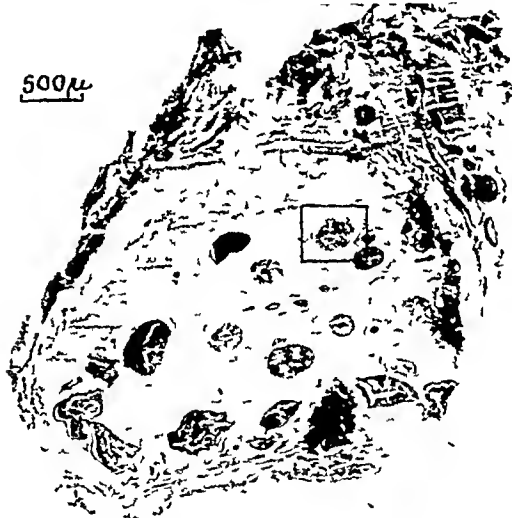


FIG 162—Graft Cross-section Compare with Fig 155 Modified protargol method



FIG 163—Graft Cross-section of bundle indicated in Fig 162 Compare with Fig 156 Absence of staining denotes lack of myelination Modified Weigert staining

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of the nerve where normally some decrease in the size of the bundles is to be expected The new fibres have progressed along the old bundles which for the most

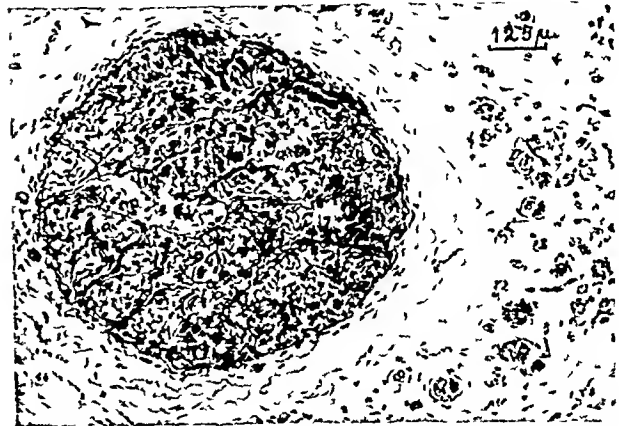


FIG 164—Graft Cross-section representing area marked in Fig 162 Densely packed non-myelinated fibres inside fascicle Numerous aberrant fibres in right side of field forming small fascicles Compare with Fig 158 Modified protargol method



FIG 165—Graft Cross-section Well-marked intra-fascicular collagenization Section of the same bundle as Figs 163, 164 Hæmalum and eosin staining

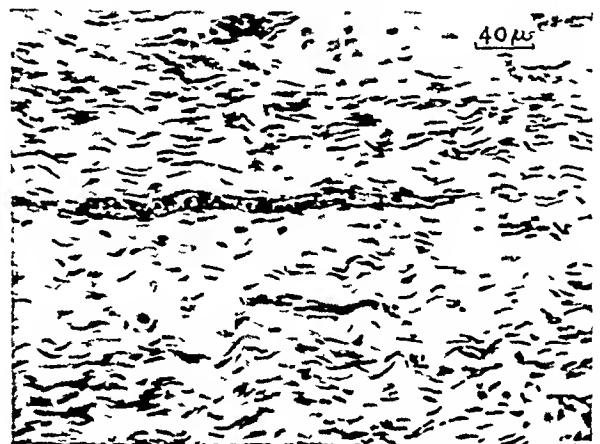


FIG 166—Graft Longitudinal section to show presence of Schwann-cell nuclei Hæmalum and eosin staining

part are densely packed with regenerating axons A few bundles, however, especially towards the middle and distal end of the graft, are but sparsely populated None of the nerve-fibres in the graft is medullated (Fig 163)



The transition from medullated to non-medullated fibres occurs abruptly immediately above the suture line. There are a number of aberrant nerve-fibres in the interfascicular fibrous tissue, which can be followed for about 20 mm down the graft. Some of these have formed themselves in small bundles and have acquired a semblance of perineurium from a condensation of surrounding fibrous tissue (Fig 164).

In cross-sections the nerve-bundles are rather widely spaced in a dense fibrous tissue (Fig 162). There is no epineurium but a thickened lighter staining perineurium. The nerve-bundles contain a large quantity of densely packed collagenous fibres and the small nerve-fibres in the old nerve-tubes seem to be pressed upon and almost strangled in the midst of this intrafascicular fibrosis (Fig 165).

A number of Schwann nuclei can be seen within the nerve-bundles in longitudinal sections (Fig 166). There are no round-celled infiltrations and no necrotic areas in spite of the thickness of the graft which appears to have been adequately vascularized, probably in part from the central end and in part by ingrowth from adjacent vessels.

### DISCUSSION

The interesting features in this case are (1) The capacity of the central stump for regeneration after 613 days, (2) After a similar long period of degeneration an autograft can receive new nerve-fibres despite the fact that the histological condition was inimicable to their maturation, (3) Although the graft had a calibre of 3 mm there was no central necrosis.

*Central Stump* It can be assumed that the regenerative capacity of nerve-fibres is a property of the neuron. Neurons rendered functionless through separation from their end-organs ultimately undergo atrophy. This inactivity atrophy may affect a number of neurons during normal regeneration as pointed out by Heidenhain (1911). "Auch bei der normalen Regeneration des Nerven werden je nach den Umständen bald mehr, bald weniger zahlreiche Fasern vom Wege abirren oder anderswie in ihrem Wachstum gehemmt werden (die Perroncitoschen Apparate sind offenbar Hemmungsbildungen), demgemäss werden in den zugehörigen Ursprungszellen dauernde regenerative Erregungszustände auftreten, welche schliesslich zur Erschöpfung und zum Schwunde des ganzen Neurons führen." It seems probable that in such neurons the regenerative power will gradually diminish and finally be lost. Collier (1940) discusses the work of Ballance, who found regressive changes in the facial nuclei and ultimate disappearance of the cells after facial nerve injury, and states "What we do not know is how long it takes for these changes to become irreversible." We can, however, find no records which would enable us to hazard even an approximate estimation of how long a functionless human neuron retains its regenerative power. Spielmeyer (1922) gives an illustration of a motor nerve-cell from the lumbar region of the spinal cord 1½ years after leg amputation. The only change noted was a hyperchromatosis of Nissl's granules. He also confirms the statement of Bielchowsky that a much larger number of nerve-cells than would be expected survive after amputation. Holmes and Young (1942) record no decrease in the nerve-fibre outgrowth from the central end of a rabbit nerve after a year and conclude that the power of outgrowth

from the central stump does not diminish during the progressive formation of a neuroma. In our case the neurons had been functionless for 613 days yet retained their regenerative power. It can therefore be concluded that within the time span of the majority of nerve repair operations a healthy central stump will contain nerve-bundles capable of vigorous nerve-fibre outgrowth.

*Graft* Even after prolonged degeneration the general architecture is preserved, although the nerve-bundles have contracted and are much smaller than normal.

Holmes and Young (1942) describe the condition of an isolated peripheral stump in rabbits after a year. They found preservation of the general structure—nerve-bundles and nerve (Schwann) tubes. The bundles were much smaller and the nerve-tubes, now less than half the size of a normal nerve-fibre, were separated by areas filled with collagenous tissue. These old peripheral stumps were still capable of receiving regenerating nerve-fibres, though some showed a diminished growth rate. They ascribe this retarded growth rate to a decline in the Schwann-cell outgrowth following delayed suture with a consequent imperfect junction, criss-crossing, and shunting of nerve-fibres. After 168 days it is not possible for us to assess the initial Schwann-cell outgrowth. There is certainly a considerable number of aberrant nerve-fibres at the junction, but a degree of irregularity and criss-crossing of fibres is to be expected at the site of suture.

The nerve-fibres have reached the distal end of the graft, but there is complete absence of medullation. It is tempting to connect this lack of medullation with the inevitable failure of the nerve-fibres to reach their end-organs, but the results of animal experiments show that medullation commences well before the nerve-fibres have arrived at their final destination (Young, 1942, Bacsich and Wyburn, 1945). Holmes and Young (1942) found that after a delayed suture of the rabbit nerve (514 days) there was no medullation and they suggest that this is due to collagenization and narrowing of the Schwann tubes which prevent the necessary preliminary increase in nerve-fibre diameter. In our case the small nerve-fibres in the midst of the abundant collagenous tissue of the nerve-bundles of the graft would have little room for expansion and it seems probable that as in the rabbit nerve the non-medullation can be attributed to the strangulating effect of intrafascicular fibrosis whereby there is no premyelination expansion of the nerve-fibres.

Seddon, Young, and Holmes (1942) describe the innervation of a fresh autograft of the human median nerve (examined after six months) by myelinated fibres which penetrated to the peripheral stump. The graft preserved its own bundles occupied by the regenerated axons, but there was marked intrafascicular fibrosis.

Sanders (1942), in his review of the methods of repair of large nerve gaps, suggests that "Revascularization of a graft of large calibre may not occur with sufficient speed to allow proper Wallerian degeneration and the centre of the graft may become necrotic." In this case there was no necrosis, although it is possible that the degenerated autograft is less

vulnerable and more able to survive the initial critical period than the fresh autograft

It is not easy to explain the negative response of the graft to faradic stimulation. It is possible that the graft was innervated largely by motor-fibres perhaps by reason of the limited contact (25 per cent) of graft and central stump. Spielmeyer (1922), however, points out that while the retrograde and regenerative changes of motor nerve-cells after injury to their axons are well recognized, little is known about the effect of axonal damage to the other types of nerve-cells. It is therefore possible that the sensory neurons may undergo more rapid inactivity atrophy than the motor neurons, in which case most of the regenerated nerve-fibres would be motor. Holmes and Young (1942) report a high threshold to faradic stimulation of the peripheral stump after delayed suture. It may be that this is the result of intrafascicular fibrosis. In our case the total lack of response can probably be attributed to a combination of these two factors—a preponderance of motor-fibres and collagenization of the nerve-bundles.

Sanders and Young (1942), in experiments with rabbit nerve, have confirmed the conclusion of Bentley and Hill (1936) that regeneration is not more rapid in predegenerated than in fresh autografts and that the only advantage of predegeneration is a firmer consistency and thus easier handling. Our results indicate, however, that this advantage would be more than counter-balanced by the disadvantage of a too prolonged predegeneration of an autograft.

### SUMMARY

1. An autograft taken from the distal end of an ulnar nerve which had suffered an irreparable injury

was sutured to the central stump, and removed 5½ months later for histological examination.

2. The central stump still retained regenerative capacity 613 days after injury.

3. The autograft survived and provided a pathway for new nerve-fibres, although none of these fibres was medullated.

4. The absence of medullation may have been due to extensive intrafascicular fibrosis which prevented normal maturation of the nerve-fibres.

5. There was no central necrosis of the autograft.

We wish to express our thanks to Dr L. Pollak for the histological reports on the nerve-stumps excised at the first operation, and to Mr A. S. Kerr who was associated with one of us in the care of the patient.

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## OBSTRUCTIVE DIAPHRAGMATIC HERNIA RESULTING FROM OLD GUNSHOT WOUND OF THE CHEST

### A REPORT OF THREE CASES

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DURING the present war the treatment of thoracic wounds has become increasingly conservative. Collections of blood or exudate in the pleural cavity are usually treated by repeated aspiration, and, in the absence of sepsis, thoracotomy is rarely performed except to remove large foreign bodies. If there has been no major mediastinal injury, transversing wounds by small high velocity missiles have done almost uniformly well, recovery has generally been complete, and the soldier has returned to duty.

But particularly in wounds of the lower chest, the diaphragm may be injured and abdominal viscera, especially the stomach and transverse colon, may be herniated into the thorax. Two such cases were recently admitted to neighbouring Base hospitals in the Middle East, each suffering from an obstructed diaphragmatic hernia of the colon as a late complication of a wound of the lower chest.

Their case histories are presented in order to direct attention to the possibility of diaphragmatic hernia being latent until complications with a high mortality supervene. A third case, with herniation of the stomach, is reported from England.

### CASE REPORTS

**Case 1—Old abdomino-thoracic gunshot wound, diaphragmatic hernia, intestinal obstruction.**

On Nov. 15, 1942, Tpr. H., aged 23, sustained a gunshot wound of the right side of the thorax between the 7th and 8th ribs, a little anterior to the mid-axillary line. The bullet finally lay subcutaneously at a corresponding point on the left side of the chest. It was removed and recovery was at first uneventful.

He was discharged to Convalescent Depot on Dec. 27. While at the Convalescent Depot, in mid-January, 1943, he had an attack of central abdominal pain and vomiting. This attack lasted only a few hours and he was discharged to duty early in February.



He remained symptom-free for nearly two months, when he had a second attack similar to the first, but lasting about a day.

The third attack, from which he ultimately died, began on April 20. Again he had central abdominal colic, with vomiting and constipation. As he did not improve in two days, during which he took fluids only, he was sent to a Field Ambulance with a provisional diagnosis of gastritis. On admission to the Field Ambulance the diagnosis was changed to subacute intestinal obstruction and the following notes were made—

Bowels not open for some days, no abnormal tenderness, tongue slightly furred, chest nil except scar.

April 23 Intermittent abdominal pain and occasional vomiting. Fluids only. Pulv alk and belladonna.

April 24 T 99°, P 72 Pain in lower abdomen, colicky in nature. Abdomen distended and tympanitic. Some resistance right side. Enema—no result except a little flatus. WBC, 20,900, 77 per cent polymorphs.

April 25 T 99°, P 100 A little flatus passed. Sull having colicky pain and returning fluid taken effortlessly.

The decision was now taken to evacuate the patient to a general hospital by ambulance car. The lateness of this decision may have been due in part to the fact that the distance was considerable, over difficult roads. The journey took nearly twelve hours, and during the trip there was copious vomiting of brown fluid.

At 23.00 hours he arrived, ill and dehydrated, at the general hospital. Admission note: "Checks slightly sunken, tongue slightly moist and clean. Abdomen somewhat distended and tympanitic above umbilicus. Large slightly tender mass in right iliac fossa. Intestinal sounds markedly increased in all areas. Rectally no abnormality detected. Some rather dry faeces in rectum. Lungs. Percussion note and breath sounds normal in all areas. T 97.4°, P 96. Continuous intravenous saline instituted. Morphine (gr ½)."

The following morning, April 26, the diagnosis of advanced intestinal obstruction was self-evident. General abdominal distension, ladder pattern, colicky pains. No vomiting since admission, rehydration satisfactory.

OPERATION, 11.00 hr (W A M)—Anaesthesia. Spinal stovaine 2 cc. Left paramedian laparotomy. General distension of small bowel except for proximal 2 ft of jejunum. Stomach empty. Small bowel plum coloured. Enormous distension of caecum and ascending and transverse colon. Obstruction by diaphragmatic hernia of splenic flexure and part of transverse colon.

To gain access to the hernia it was necessary to make a secondary oblique incision from just above the umbilicus to the subcostal margin in the neighbourhood of the 10th left costal cartilage. The cartilaginous margin was divided and the incision continued, to open the pleural cavity. The tight hernial ring situated centrally in the left dome of the diaphragm was enlarged by a radial incision and the herniated mass, consisting of 18 in of colon and almost all of the great omentum, was returned to the abdominal cavity. The colon was clearly viable but the omental mass was in part necrotic and so it was removed. Diaphragmatic opening closed with interrupted sutures of heavy catgut with an overlay of fine catgut. Closure of the abdominal incision proved difficult, and it was necessary at this stage to give ether. The anal sphincter was stretched and a rectal tube inserted allowing escape of a considerable volume of foul black fluid faeces which had passed onward following relief of the obstruction.

During the course of the operation the patient had two pints of blood and one pint of glucose-saline. His final condition was satisfactory, but he was 'chesty'.

PROGRESS—Following operation, his condition steadily deteriorated. He presented persistent and resistant cyanosis, much bronchial fluid, and there were signs of

peripheral vascular failure. Venoclysis was discontinued. Continuous oxygen administered with partial good effect. Coramine in adequate dosage had no appreciable effect. Morphine (gr ½) was given with atropine (gr 1/100). Deterioration, however, continued throughout the day, pulse-rate varying from 140 to 180 per minute and pulse volume very variable.

The following morning, April 27, at 05.00 hr signs of impending death were apparent. Marked peripheral vascular failure and noisy dyspnoea. Partial left pneumothorax noted. 500 cc air withdrawn from left chest with diminution of signs of pneumothorax and temporary improvement of pulse, which became steady at 140 per minute. Glucose-saline venoclysis recommended and morphine and coramine repeated.

At 06.45 hr he regurgitated unaltered a few ounces of water which he had drunk since operation and cardiac respiratory action ceased.

AUTOPSY—This was carried out at 10.00 hr by Major S C Buck, R A M C, who reports as follows:

"Well-developed muscular man. Rigor mortis present throughout. Dark red frothy fluid issuing in large quantities from mouth and nose. Sutured left paramedian wound, with subcostal extension.

"Peritoneal cavity contains about 15 oz of blood-stained fluid. All coils of small bowel matted by light fibrinous exudate. Serous surfaces congested, with scattered subserous haemorrhages. Mucosa oedematous in proximal part. Moderate distension of all except lowest 40 cm of ileum. Colon contains dark faeces throughout, serous surface of transverse colon shows a few small dark haemorrhagic patches. Mucosa of this part markedly oedematous, giving the appearance of colourless jelly.

"Sutured wound about 8 cm in left dome of diaphragm. The diaphragm is adherent to the left lobe of the liver and the chest wall deep to an old linear scar 1.5 cm long in the skin over the 8th left intercostal space. Similar adhesions between right dome of diaphragm and right lobe of liver and chest wall, corresponding with a circular scar, 0.4 cm in diameter, in right chest wall. Section of liver shows just visible fibrosis along old missile tract.

"About 8 oz of blood-stained fluid in left pleural cavity. Left lung quite free, collapsed, and almost entirely airless. On section dark red fluid flows copiously. Right lung moderately well aerated except for lower lobe, which exactly resembles left lung. Right pleural cavity obliterated in lowest part by fibrosis extending as high as 4th rib in paravertebral gutter.

"Remaining abdominal organs congested but otherwise normal. Bladder distended. Brain not examined.

"Cause of Death: Old gunshot wound, thorax and upper abdomen. Operation: Reduction and repair of traumatic diaphragmatic hernia (left). Paralytic ileus and respiratory embarrassment."

#### Case 2—Old abdomino-thoracic shell wound; diaphragmatic hernia, intestinal obstruction

In 1940, during the battle of France, Bdr V, aged 22, was wounded in the left side of the chest. He was evacuated to England and made an uninterrupted recovery, returning to duty as an A1 soldier. He then remained well until January, 1943, when he had an attack of severe colicky abdominal pain with vomiting and absolute constipation, which lasted for five days and from which he made a complete recovery. The attack ceased abruptly when he passed a large quantity of flatus.

His second and fatal attack began on June 23, 1943, when, after strenuous exercise, he was seized with severe abdominal pain, colicky in character, and vomited several times without obtaining relief.

On June 24 he was admitted to a Field Ambulance and the next day two enemata were given without result. It was then realized that he was suffering from intestinal

obstruction and he was transferred to the Base hospital. During this initial 48-hours' period of his illness colicky circum-umbilical abdominal pain had persisted. He had continued frequently to vomit and he could pass neither faeces nor flatus.

**ON ADMISSION**—The patient's general condition was surprisingly good. T 98.4°, P 84. Tongue was moist but slightly furred. The abdomen presented slight epigastric distension, there was no rigidity, but there was some deep tenderness in the epigastrium and right iliac fossa. Peristalsis could not be seen and the potential hernia orifices were empty.

Per rectum nothing abnormal was found. Chest. Apex beat was well medial to the left nipple in the 5th interspace, although it was 3½ in from the midline. There were no abnormal cardiac sounds. There was a scar 1½ in long in the left 7th interspace at the anterior axillary line (scar of the shell wound sustained in France in 1940).

Lungs showed slight diminution in breath signs over the left base. Screen examination and radiograph revealed the presence of a hernia through the left dome of the diaphragm with a distended coil of large intestine inside the left pleural cavity. There was also marked dilatation of the colon below the diaphragm proximal to the hernia. A small piece of shell splinter was present in the right lobe of the liver.

**PROGRESS**—On admission a continuous intravenous saline drip was instituted. An enema was given from which there was no return of faeces, and continuous gastric suction was begun.

The next day, June 26, he was more comfortable, he was free from pain and had passed flatus per rectum. During the next two days, June 27 and 28, his condition remained good, he continued to pass flatus per rectum, and it was hoped that he would overcome this his second crisis of acute intestinal obstruction. However, on the evening of June 28 his temperature rose to 100° F, and the pulse-rate to 100. There was some increase in abdominal pain and his condition was not so good.

By the early morning of June 29 his condition had further deteriorated, and there was increasing abdominal distension.

Cæcostomy was performed, but it did not function efficiently. He continued to deteriorate and died in the early hours of June 30, after his temperature had risen to 105° F.

**AUTOPSY**—This was carried out by Major H. A. Magnus, R.A.M.C., who reports as follows: "Well-developed, muscular man. Rigor mortis present, and there was a small old linear scar in the left 7th intercostal space and recent incision in the right iliac fossa. No evidence of peritonitis, but the small intestine greatly distended and congested."

"Diaphragmatic hernia. The left half of the transverse colon and the splenic flexure pass through a hole in the left dome of the diaphragm into the left pleural cavity. The whole of the intrathoracic portion of the colon is greatly distended, as is also the proximal colon, including the cæcum. The colon distal to the hernia is empty and contracted. The hole in the diaphragm is round and 4.0 cm in diameter, situated in the muscular part of the left dome, slightly to the right of its centre. The efferent limb of the herniated colon is densely adherent to the edge of the hole in the diaphragm on its upper surface, and compressed against the edge of this hole by the tense and distended afferent limb of the herniated colon. At the neck of the sac the descending portion is compressed, partly by adhesions and partly by the pressure of the greatly distended afferent limb. There is no infection round the cæcostomy. A small piece of shell is firmly embedded in the upper surface of the right lobe."

"Right pleural cavity and contents normal. Left pleural cavity contains a small quantity of fluid and the left lung is pushed upward and medially and partially collapsed by the greatly distended intrathoracic portion of the large bowel. No evidence of infection of the left pleural cavity. The remaining organs are normal."

**Cause of Death**—Old shell wound of thorax and upper abdomen, paralytic ileus secondary to obstruction of large bowel, herniated into thorax."

**Case 3—Old penetrating bomb wound (mortar) of left chest, diaphragmatic hernia**

Pte McC., aged 19, was wounded in France shortly after D day, June 19, 1944. A small fragment of mortar bomb traversed his left arm, injuring the median and ulnar nerves, entered the left thorax, and lodged toward the back of the left chest cavity. Radiography of the chest showed a small hæmothorax. He made an apparently uncomplicated recovery and was shortly transferred to a neurological centre for treatment of his nerve lesion.

In September, 1944, an operation was performed on his left arm. In the immediate post-operative period he had fairly severe epigastric pain. This subsided after a few hours, but recurred some days later and thereafter with increasing frequency until it was practically a daily occurrence. He went on sick-leave on Jan 8, 1945. While on leave he began to vomit and thereafter vomited practically everything he ate.

He was admitted to an E.M.S. hospital in the south of England on Jan 15. His admission note states: "Pale, ill, and wasted. Slight tubularity of breathing in right axilla. Abdomen N.A.D."

On Jan 17, he was X-rayed, and the following report made: "Left dome of diaphragm high. No pulmonary lesion. Paravertebral foreign body present. Stomach appearances suggest 'cup and spill' stomach." Blood-count showed a slight degree of anaemia, but no significant abnormality.

On Jan 25 he was X-rayed again with barium. On this occasion the stomach did not show the 'cup and spill' appearance, but barium was still present in the stomach after 8 hours. Examination of the faeces for occult blood was negative. While in hospital his general condition did not improve, and on Jan 30 he began to vomit dark-brown fluid containing altered blood and deteriorated rapidly. On Jan 31 he was seen in consultation by one of us (W.A.M.) at 15.10 hr. He was pale and complaining of intense thirst. He was pale fluid, and obviously dehydrated. T 99°, pulse-rate 90, and small in volume. Values for blood-urea (48 mg per cent) and blood-chlorides (262 mg per cent) became available at this time. A clinical diagnosis of post-traumatic diaphragmatic hernia was made and study of previous meal pictures of Jan 18, 1945, indicated that at that time the greater part of the stomach was intrathoracic.

Glucose-saline venoclysis was begun and the patient was transferred by ambulance to a military hospital. In the course of the journey he received 2 pints of saline intravenously and his condition improved somewhat. Condition on admission. T 97.4°, P 76, R 20. Venoclysis continued. Four pints of saline were given followed by 1 pint of plasma. It was desired to estimate the urinary chlorides, but unfortunately despite careful instructions the specimen passed at this time was discarded. At 20.00 hr a tube was passed transnasally into the stomach and suction drainage established. About a pint and a half of brown fluid was aspirated. Further X-ray examination showed the herniation of the stomach to be still present though comparatively small in size, and the stomach tube directed upward into the left hypochondrium toward the presumed opening in the diaphragm.

At 22.00 hr hydration appeared complete. T 97.2°, P 80, R 20, BP 120/94 mm Hg. Pulse full, colour

good Operation was performed at 22.15 hr under intratracheal anaesthesia. The 9th left rib was resected and the thorax opened. There was an opening 4 cm in diameter in the left dome of the diaphragm and through this there projected upward a hernial sac composed of omentum and containing the greater part of the stomach. There was one small adhesion to the lower margin of the lung and the stomach wall was densely adherent to parts of the margin of the hernial ring, in the neighbourhood of which there was much inflammatory oedema. The opening was slightly enlarged, adhesions divided, and stomach and omentum reduced into the abdominal cavity. The diaphragm was closed with interrupted sutures of stout silk, with an overlay of catgut. It was not necessary to interfere with the phrenic nerve. A catheter was introduced through the 10th space into the costophrenic sulcus, and after complete inflation of the lung the thoracic wall was closed in layers. A pint of blood was given during the operation and the patient left the table in good condition. Venoclysis and gastric aspiration were continued for 24 hours. The intercostal catheter was removed in 48 hours. Recovery was uneventful. On Feb. 13 four ounces of serous fluid were aspirated from the pleural cavity.

**X-ray Appearances**—From a large series three radiographs are shown, taken on July 3, 1944, Jan. 18, 1945, and Jan. 31 (Figs 167-169). It is easy to be wise in retrospect, but it may fairly be suggested that even on July 3, 1944, diaphragmatic hernia should have been suspected, for in addition to the presence of a small amount of fluid at the left base the film shows a well-defined air-containing saccululation extending considerably higher than the normal level of the left dome of the diaphragm. That of Jan. 18, taken after administration of barium, shows clearly the greater part of the stomach, ballooned out by gas and fluid with a little barium, in the thorax, the oesophagus dilated and ending in a saccular

material in deciding upon operative intervention as soon as fluid and salt balance was restored. The operative procedure proved extremely simple as intrathoracic adhesions were slight. Intratracheal anaesthesia gave



FIG 168—Radiograph taken on Jan 18, 1945. The oesophagus filled with barium, is dilated, and terminates in a small spherical saccululation (the cardia) showing a double fluid level of fluid and heavier barium. Above and to the patient's left is a great sac consisting of the greater part of the patient's stomach filled with gas, fluid, and a little barium. This communicates by a narrow neck with the pyloric portion of the stomach below. Metallic foreign body is clearly seen.



FIG 167—Radiograph taken on July 3, 1944, showing considerable opacity in left lower chest, in the upper portion of which a gas-containing cavity is seen.

cardia with two fluid levels, and the pyloric antrum dropping straight down to the duodenum, dragging it to the left. The pre-operative radiograph on Jan. 31, after aspiration of the stomach, shows persistence of the gastric herniation and the transnasal tube curving up and to the left.

**Comment**—Experience of the two previous cases made a clinical diagnosis in this case easy and it was



FIG 169—Pre-operative radiograph on Jan 31, 1945. The fundus of the stomach is clearly seen above the diaphragm and the intragastric tube is seen curling upward and to the left.

control of the lung, and by its means, reinforced by post-operative breathing exercises, it was possible to avoid any post-operative pulmonary complication. The small metallic foreign body did not present, and no search was made for it. Swinney (1942) reports a case of gastric diaphragmatic hernia following a knife wound. Conservative measures failed utterly and the patient was cured by thoracotomy and reduction and repair of the hernia.

## DISCUSSION

Three cases are reported of diaphragmatic hernia following wounds of the lower thorax sustained some time previously. All were acutely ill when first seen, suffering from obstruction bordering on strangulation. One, in which the stomach had herniated into the thorax, recovered uneventfully following operation and need not be considered further. Two, in which the colon was involved, died. It may be profitable to attempt to assess the factors which contributed to the fatal issues. The following observations are offered—

1 Diagnosis was delayed. In both cases the fatal attack was preceded by others which resolved spontaneously. Thorough investigation of these earlier illnesses would have established the diagnosis and might well have permitted repair during a relatively safe interval period.

2 In both cases, in the final illness, there was considerable delay before the patient was sent to hospital, in *Case 1* five days, in *Case 2* two and a half days.

3 In *Case 1* the pre-operative diagnosis was incomplete. He was operated upon as a very ill emergency. But X-ray examination of the chest and abdomen would have completed the diagnosis, and had this been accomplished the thorax alone would have been opened and intratracheal anaesthesia used. Operation would have been shorter and less severe, collapse of the left lung would have been avoided, and he might well have recovered.

4 In *Case 2* caecostomy failed to benefit. Conservative measures appeared at first likely to be successful, but he suddenly deteriorated and caecostomy was performed as a minimal emergency procedure. Its failure may be associated with the fact that it did nothing to relieve the obstruction, with partial strangulation, of the herniated loop.

It is fortunate that herniation of the colon through the diaphragm is rare, for it is associated with considerable risk to life. This is mainly because the lesion may readily set up two closed-loop obstructions, the distal being the herniated bowel inside the thoracic cavity, the proximal the colon between the ileocaecal valve and the hernial ring. In addition the herniated loop may be strangulated. The gravity of the proximal obstruction depends upon the fact that, if the ileocaecal valve remains competent, considerable pressures may be attained in the caecum and proximal colon, which become enormously distended and suffer gross damage to mucosa and vasculature. It has been shown by Knight and Slome (1935) that obstructive

distension of a loop of bowel results in compression of the blood-vessels in the mucosa. Absorption is slight during this phase, but toxic substances are elaborated in the lumen and gut wall, and these are freely absorbed if the pressure is suddenly relieved, with production of phenomena akin to 'shock'. Fatal toxæmia may therefore occur after a mechanically successful operative intervention. This toxæmia may have been a factor in producing the fatal issue in *Cases 1* and *2*.

It is not possible to state categorically what is the correct order of procedure in all cases of obstructed diaphragmatic hernia of the colon. It is possible that an early caecostomy might relieve the acute emergency and permit of repair of the hernia in conditions of safety. Since, however, the herniated loop may be strangulated it is clearly dangerous to leave it unexplored unless the duration of the obstruction has been short, its degree incomplete, or the response, controlled by X-ray findings, to conservative measures such as gastric aspiration, caecostomy, and venoclysis, entirely satisfactory. The correct approach to the hernia is by thoracotomy, and in the absence of obstruction or after its relief, reduction and repair of the hernia is a comparatively simple matter.

But as in all rare conditions, efficient treatment of traumatic diaphragmatic hernia depends mainly on sharp awareness of the possibility of its existence. It is probable that purposive investigation of all cases which have suffered a traversing injury of the lower thorax would bring to light unsuspected cases of diaphragmatic hernia. Barrett (1945) quotes a case in point. Certainly the occurrence of even mild obstructive symptoms should bring such cases at once under surgical care. It should then be possible, after accurate investigation, to carry out with precision the surgical measures necessary to save life.

## SUMMARY

- 1 Three cases are presented of diaphragmatic hernia following missile wounds of the lower thorax.
- 2 Attention is drawn to the latency of the condition and to the gravity of its complications.
- 3 Some aspects of its management and treatment are briefly discussed.

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## PELVIC ECTOPIC KIDNEY

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CONGENITAL abnormalities of the kidneys and ureters are comparatively common and, according to Gutierrez (1936), 40 per cent of all pathological conditions of those organs are due to congenital anomalies. A large proportion of these abnormalities

fall into the category of renal dystopia. By definition, "an ectopic kidney is one that owes its position to developmental failure, it has been arrested in ascent during embryonic life and usually has failed to rotate" (Thompson and Pace, 1937). The

congenital displacement may affect one kidney, which is comparatively common, or may involve both, which is rare. Further, the dystopia may be crossed or uncrossed. The arrest in ascent may occur at any point along the normal course of the ureter, and the kidney or kidneys may be located in the lumbar region, on the iliac vessels, on the pelvic brim, or resting in the hollow of the sacrum. These positions, according to Brown (1931), correspond to the situations of the little ring muscles of the ureter described by Kelly. When both kidneys are ectopic or when crossed dystopia of one kidney is present, fusion of the kidneys to a greater or lesser extent commonly occurs. This leads to the production of horseshoe kidney with fusion at the upper or lower poles, or to the development of a 'concreescent' or 'cake' kidney, which may be found in the prevertebral region of the lumbar spine, situated to one or other side of the spine in crossed dystopia, or in the pelvis. When fusion occurs two ureters are present, as the conglomerate mass arises from the confluence of the primordia after the formation of the ureteric buds from the Wolffian ducts.

Unilateral pelvic ectopia of the kidney is not an extreme rarity, and several hundred cases of this condition have been reported in the literature. From time to time such cases are diagnosed clinically and the frequency of their ante-mortem discovery has greatly increased with the development of the cystoscope. In post-mortem material the incidence is certainly less than 1 in 2000 cases (*Table I*). Bilateral pelvic kidney is even less frequently encountered and is therefore a very rare condition indeed.

*Table I*—INCIDENCE OF UNILATERAL ECTOPIC PELVIC KIDNEY

AUTHOR	NUMBER OF CASES	NUMBER OF AUTOPSIES	INCIDENCE PER 1000 AUTOPSIES
Thompson, R (1914)	1	13,505	0.07
Stewart and Lodge (1923)	3	6,500	0.46
Shore (1930)	1	1,464	0.68
Thomas and Barton (1936)	7	22,000	0.32
Thompson, G J and Pace (1937)	3	11,000	0.27

### ANATOMICAL PECULIARITIES

The ectopic pelvic kidney is usually smaller than a normal kidney and is malformed. It may be moulded into the hollow of the sacrum or, if it lies on the iliac vessels, it will present a ridge on its posterior surface to accommodate those structures. Failure of normal axial rotation results in the hilum facing anteriorly, and, while the ureter is short and tortuous, it enters the bladder in the usual situation. The calibre of the ureter may be normal or may be less than average. The blood-supply is always abnormal, and it is this finding which, among others, distinguishes a congenital malposition from the usual type of ptosed kidney. The blood-supply is derived from the neighbouring arterial trunks and the aberrant vessels represent transient arteries which normally disappear as the kidney migrates to

its position in the loin. These vessels spring from the external, internal, or common iliac arteries, and it is usual to find a renal artery arising near the bifurcation of the aorta. This vessel may replace the middle sacral artery or may be independent of it. Veins from the kidney drain into the iliac veins or into the lower end of the inferior vena cava. The normally placed kidney is held in position by the pressure of the 'intrapertitoneal' abdominal organs, and by the perirenal fat. The ectopic pelvic kidney has no perirenal fatty capsule and its stability depends on its being retroperitoneal, on abnormal adhesions, or on the presence of more than one set of vessels entering the hilum from different directions. Sometimes the kidney may be found in the mesosigmoid or in the broad ligament (Herman, 1938) or, exceptionally, it may have a mesentery of its own (Ransohoff, 1920). Because of its separate embryological origin, the suprarenal gland on the affected side is normally situated but shows none of the moulding associated with its close apposition to the upper pole of the kidney.

### EMBRYOLOGICAL THEORIES OF ECTOPIC PELVIC KIDNEY

The gross embryology of the upper genito-urinary tract is, in general, accepted as established and final. The ureteric buds appear in the 5-mm human embryo and arise from the Wolffian ducts a short distance from their entrance into the cloaca. Each bud, which forms the collecting part of the kidney, grows into the metanephros, which forms a cellular cap on it and from which the secretory portion of the kidney is developed. The embryonic kidney, which at first is situated in the pelvis, ascends in the line of the degenerating mesonephros, undergoes axial rotation, and reaches its adult position by the end of the second month of intra-uterine life. The cause of this migration is not known. The theory that the ureteric bud pushes the metanephrogenic tissue upwards is not now generally accepted, and it may be that the ascent is more a matter of differential growth than true migration (Gruenewald, 1939). The ectopic pelvic kidney, therefore, represents an arrest in the normal ascent of the kidney and a corresponding failure in its axial rotation. It is clear that, whatever the cause, the defect must originate early in embryonic life and, due to the arrest, the temporary blood-supply becomes permanent.

The cause of the arrest is still the subject of discussion. One theory, attributed to Lemberger by Lucas (1934), is that it may be due to a failure of the ureters to elongate after a certain stage. This seems untenable, according to Brown (1931), who holds that early arrest in elongation of the ureters is accompanied by complete cessation of kidney development. This must depend on what is meant by 'early arrest' because an ectopic pelvic kidney has a short ureter and yet may function normally. It appears to be true that unless the ureteric bud makes contact with the metanephrogenic tissue, which is to form the secreting portion of the kidney, a normal functional kidney will not develop, suggesting, therefore, that the ureteric bud is concerned with organizing the differentiation of the

metanephros. A second theory (Lucas, 1934) is that excessive enlargement of the Wolffian bodies may cause their caudal ends to adhere to the metanephros and so may prevent the latter from detaching itself. Further, this hypertrophy of the Wolffian bodies may force the developing kidneys closer to the midline and into contact with one another, and it forms an attractive explanation of the origin of fused kidneys. There seems to be no theoretical objection to the postulation of unilateral hypertrophy of the Wolffian body thus retaining one kidney in the pelvis. A further theory (Carleton, 1937) is that anomalies in the origin of the umbilical artery may obstruct renal ascent. Ransohoff (1920) thinks that the arrest may be due to the abnormal origin of the renal artery from the iliac arteries. This opinion would not, I think, meet with general acceptance as it seems much more reasonable to suppose that the abnormal vascular supply is due to the ectopia and the survival of embryonic vessels than vice versa.

### PATHOLOGICAL CHANGES IN PELVIC KIDNEYS

It is a generally accepted fact that if an organ is abnormally developed it is much more liable to disease than one of normal conformation and location. While this may be true, many pelvic kidneys cause no symptoms during life, and this accounts for the discrepancy between the incidence of their discovery clinically and at autopsy. In the series published by Thompson and Pace (1937), the clinical incidence of all forms of renal ectopy is estimated at about 1 in 10,000 cases, and that of the pelvic variety must be considerably less. The post-mortem incidence is in the neighbourhood of 1 in 2000 cases. The condition may be detected during a routine genito-urinary investigation or may be discovered in the course of a post-mortem dissection (De and Sinha, 1934, Pan, 1924, Shore, 1930, Smith and Boulgakow, 1925, and Gilman, 1927).

A pelvic kidney may cause dystocia but cases have been reported where normal delivery was achieved in spite of the additional pelvic organ. As the kidney lies in the pelvis on a similar level to the bladder, drainage from it is bound to be defective and, consequently, such an organ is more liable to infection and calculus formation than its normally placed fellow. According to Herman (1938), ectopic kidneys are predisposed to hydronephrosis and pyelonephritis, but there is no reason to suppose that they are more liable to tumours, tuberculosis, or injury than a normal kidney (Thompson and Pace, 1937).

Usually the kidney is firmly fixed in its abnormal position, but, if this is not so and it possesses a mesentery, torsion may occur. The only recorded case of this kind is that of Ransohoff (1920), where the kidney was suspended by a mesentery from the posterior pelvic wall and the gangrenous kidney was removed successfully by operation.

### CASE REPORT

**HISTORY**—A male child, which was born ten weeks premature and weighed 4½ lb at birth, appeared to thrive and had no illness until he was two months old. During the first day of his illness he had diarrhoea, cried a lot,

and kept drawing up his legs. He took all his feeds normally that day but during the night he was very restless and kept crying. Next day, the child took two feeds and appeared to be better, but in the early afternoon he was found dead in his cot.

**AT AUTOPSY**—The child's body weighed 5 lb 8 oz and was 19 in long. The left scapula was situated higher than usual, producing a deformity of the left shoulder, and the left side of the head and face was smaller and flatter than the right. No gross abnormality was noted on opening the abdomen, but when the bowel had been displaced a dark-purple retroperitoneal swelling



FIG. 170.—Post-mortem photograph. A, Left suprarenal gland, B, Left renal artery, C, Left renal vein, D, Left kidney, E, Left ureter, F, Bladder.

was noticed in the hollow of the sacrum. This swelling was suspended from the posterior wall of the pelvis by a short, twisted mesentery. Reduction of the torsion and further exploration of the abdomen revealed that the swelling was a deeply congested pelvic kidney. The right kidney and suprarenal were healthy and normally situated. The suprarenal occupied its normal position but was round and discoid instead of crescentic, presumably due to the absence of moulding on the upper pole of the kidney. The left kidney was flattened from hilum to lateral border in order to fit into the hollow of the sacrum and was smaller than normal. In its natural position the hilum faced anteriorly and the vessels emerging from it ran up over its upper pole. The ureter was short and tortuous, and its diameter was increased by comparison with its fellow. The renal artery was single and arose from the bifurcation of the aorta in precisely the situation one would expect to find the middle sacral artery. This vessel was absent. The left renal vein flowed into the right common iliac vein just distal to the point where the two common iliac veins unite to form the inferior vena cava (Fig. 170). The



kidney was dark purple in colour, due to strangulation of its blood-supply, and on histological examination it was found to be intensely congested with multiple hæmorrhages throughout its substance. An interesting feature was that in the pelvic kidney all changes from slight thickening of the glomerular capsules to advanced fibrosis and hyalinization of the glomeruli were noted. The causation of these changes is uncertain but they may perhaps have been due to defective blood-supply, as corresponding changes were not found in the normally placed right kidney. It is clear, therefore, that the pelvic kidney would in time have become functionally inefficient. No significant abnormalities were found in any other system.

**Comment**—A search of the available literature on this subject has revealed that, with the exception of the case reported by Ransohoff (1920), no case similar to this one has yet been described. This kidney possessed a short mesentery and only one set of vessels. The presence of a mesentery and the absence of fixation rendered torsion a possibility, and it is interesting to note that in Ransohoff's case also there was only one renal artery. This, I think, is important. In most cases of pelvic ectopic kidney reported, multiple renal arteries and veins are described and these vessels frequently arise from different trunks often on both sides of the body. The factor which precipitated the torsion was probably the increased peristalsis engendered by the diarrhœa.

Many other congenital defects have been described in association with renal ectopy. These defects, as would be expected, mainly affect some other part of the genito-urinary system and may appear as absence or deformity of the pelvic viscera or external genitalia. Guizzetti (1918) states that anomalies of the genitalia are present in one-third of the cases of congenital renal abnormality. Associated defects of the bowel have been described by Looney and Dodd (1926), and in one case Thompson and Pace (1937) noted an absence of the frontal sinus. Widespread developmental defects, affecting structures embryologically unassociated, have thus

been found in cases of renal ectopy. This suggests that a germinal defect of one-half of the body may be the responsible factor.

### SUMMARY

- 1 The incidence and anatomical peculiarities of ectopic pelvic kidney are reviewed.
- 2 The embryological theories on the subject of this deformity are considered.
- 3 The pathological changes to which such a malplaced kidney is liable are discussed.
- 4 A case of torsion of a pelvic kidney in an infant is described.

I am indebted to Detective Sergeant Kenneth Moore, of the City of Sheffield Police Photographic Department, who was responsible for the photograph.

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## TORSION OF THE GREAT OMENTUM

### REPORT OF FOUR CASES

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INTRA-ABDOMINAL torsion of the omentum is not common as reviewed in the literature. It is certain, however, that many cases have not been reported. The variety of torsion of the whole great omentum in the absence of any hernial history or discoverable intra-abdominal causative lesion is rare. Of this primary, idiopathic, or simple type, up to December, 1944, there are now recorded about 73 cases including 1 case of my own. The remaining 3 personal cases are also examples of abdominal torsion of the whole omentum, of the secondary class, i.e., two were bipolar with a pelvic adhesion and the last case swollen and infected by tubercle bacilli. Marchette (1851) and Oberst (1882) are credited with the reports of the first 2 cases of secondary

torsion, hernia being present in each case. Eitel (1899) noted the first case of primary torsion. Rudolph (1903) is the only one previously credited with 4 cases. My four specimens are illustrated in Figs 171-4. Most surgeons of experience must have come across omental (other than great omentum) and epiploic tags adherent and torsioned. I have seen 2 such cases, 1 being in connexion with the gastro-hepatic omentum. Such cases are not discussed here.

The great omentum may twist as a whole, or as a part or strand, either may be complete (strangulated) or incomplete (congested), either may be primary or secondary. Primary twists are necessarily intra-abdominal and unipolar and no definite



cause can be assigned. Secondary rotation cases may be uni- or bi-polar, a hernia, adhesion, cause for omental deformity, or evidence of past or present intra-peritoneal inflammation being present, the omentum may be entirely intra-abdominal, wholly in a hernial sac, or there may be combined hernial and abdominal rotation. The condition may be acute or subacute, and there are probably recurrent cases.

Of all varieties some 190 cases are recorded in the literature.

### CAUSATION

Though still speculative, it must be clear that a combination of factors are responsible—some predisposing, such as peristaltic pushes by the muscle of the intestines, abdominal wall, and diaphragm, sudden jerky body actions and rotations, direct blows, omental disfigurement by tumours, overloading, or uneven fat distribution, pedicle formation, scarring, raggedness, adhesions, and bi-polar attachments, displacement of the omentum during operation or by abdominal tumours. A history of all such cases is found among the cases recorded. A partial twist having started and caused congestion of the veins with œdema, it has been suggested (Payr) that the shorter and firmer arteries may complete the omental writhing. Any other condition producing œdema of the omentum, e.g., the heart or adjacent peritoneal inflammation, might produce the same result. *Case 1* of my series followed almost immediately after the cranking of a motor car. *Case 2* had a severe jolt the day before onset, had a right inguinal hernia (empty sac), and a bi-polar torsion. *Case 3* had a failing heart from severe untreated thyrotoxicosis, a hernial operation scar, and bi-polar torsion. In *Case 4* tuberculous inflammation of a the great omentum was present. If it is comprehensible that a bi-polar or peg-top torsion can take place in its smooth-lined cavity by any or a combination of the above factors, then one must assume that the same conditions play their part in the hitherto difficult aetiology of idiopathic torsions. It is not difficult to imagine how a hernial ring with entering omentum will lead to secondary axial rotation. Is not the same condition present, multiplied, in the crevices and potential spaces among the viscera and peritoneal folds of the packed abdominal cavity in primary torsion? Any argument suggesting that primary torsion would result more frequently appears unreasonable because such commencing torsion of an omental border or strand among smooth structures will invariably be temporary and right itself. It is, moreover, considered that such slight degrees of axial rotation may account for fugitive abdominal pain, so difficult of diagnosis. Furthermore, there is evidence that even more advanced rotation may untwist spontaneously. Observation of the great omentum during routine operations shows its great mobility, its wanderings, variable size, raggedness, surface irregularities due to fibrosis, and uneven distribution of fat. The heavy, long, and distally wide omentum appears the more susceptible to torsion, judging by my cases and the majority of the reports. It has been well said that mobility is imparted by postures and peristalsis, pulsations, and pulls, percussions and

punches—to which may be added pinches, pouches, and plastics. Much interest and speculation has been shown in the aetiology of axial rotation of tissues, and it is apparent that more than one factor is responsible in torsion of the whole great omentum.

### SEX AND AGE

Males are more often affected than females, an incidence which may be accounted for by trauma or exertion. In the primary cases 42, or 59 per cent, were males, and 29, or 40 per cent, females. The largest numbers of cases fall in the age group 30–55 years (65 per cent), very uncommon at the extremes of age. The youngest were aged 5, 7, 7, 12, and 21 years, 2 cases aged 63 were in the idiopathic group. Among secondary cases the ages of 1 and 3 years are mentioned, but the age grouping is very similar to the above.

### CASE REPORTS

*Case 1*—W L, male, aged 50. No previous abdominal history, not obese. Sudden pain in epigastrium Dec 8, 1926, after winding starter of car. Worked that day with discomfort. Next day condition the same, stayed at home. On Dec 10, examined, complained of lower right-sided pain and soreness. T 99.6°, P 100. Felt sick. No vomit. Tenderness and slight rigidity rather high for an appendix. No inguinal hernia.



Fig 171—*Case 1*. The twisted omentum (Actual size)

Later that night, T 102°. Dec 11, morning, T normal, P 100. Very tender, hurts to move in bed. Indefinite swelling present high in right iliac fossa. Diagnosis (?) appendix abscess. Operation same morning. Appendix normal. Sero-sanguineous fluid in abdomen. Mass consisting of the whole great omentum acutely torsioned and purple, with no adhesions (Fig 171). Lower extremity narrow and pedicled, 3–4 anti-clockwise rotations. Recovery. A case of acute, primary, intra-abdominal torsion of the whole great omentum.

*Case 2*—W L, male, aged 57. Right inguinal hernia with empty sac. July 5, 1939, gradual onset of abdominal discomfort and pain in right abdomen settling in lower right quadrant. Patient considered it was due

to a fall the day before. Admitted July 6 at 10 a.m. complaining of abdominal pain and soreness, nagging and not severe. During the night there was frequency and pain during micturition. T 99.2°. Tender in right iliac fossa. Diagnosis, appendicitis. No nausea or vomiting. Seen again at 1 p.m. and operated. A long, heavy, deeply congested, fat great omentum, located in the midline, completely torsioned 2½ turns clockwise, tightened by a firm old-pointed fibrous adhesion to the posterior wall of the bladder, was removed (Fig. 172).

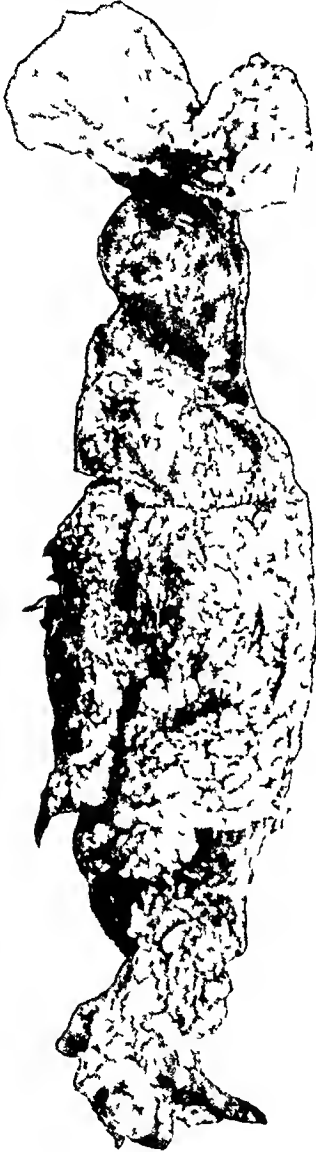


Fig. 172—Case 2. The specimen ( $\times 4$ )

**Appendicectomy.** Sero-sanguineous fluid in abdomen, much oedema of tissues, especially near the transverse colon attachment, which was devoid of fat. This thinned-out omental upper border had formed the pedicle and immediately below it was a rounded firm mass of fat suggestive of a lipoma in the omentum. Recovery. A case of acute, secondary, intra-abdominal, bipolar torsion of the whole omentum. The fibrous firm-pointed adherent end of this peg-top omentum had almost certainly acquired its inflammation in the past from entry and exit into the right inguinal sac.

**Case 3—W. I. S., male, aged 38.** An untreated acutely thyrotoxic patient with a pulse of 130 on admission. Scar of repaired right inguinal hernia present. Twelve hours before operation he was seen by his doctor at night with severe right upper abdominal and epigastric pain and vomiting, and thought to be gall-bladder. Admission Sept. 24, 1941. Large pulsating thyroid, exophthalmos. P 130, T 100°. Rigid and groaning in pain (? exaggerated). Tender whole of right side of abdomen. Tentative diagnosis, perforated duodenal ulcer. At operation a well-loaded completely torsioned whole great omentum adherent by fibrous strands to the pelvic floor, showing no obvious signs of gangrene, was untwisted and the abdomen closed hurriedly. A fair amount of clear pinkish-yellow fluid was contained in



Fig. 173—Case 3. The specimen (Actual size)

the abdomen. The patient died a few hours later. The omentum was recovered post mortem the same day and was found untwisted but easily adjusted back into the rotated position seen at operation. The lower pole was firm and bound together by fibrosis and may easily have become inflamed by entering his hernial sac in the past (Fig. 173). A case of acute, secondary, intra-abdominal, bipolar torsion of the whole omentum with some oedema due to severe thyrotoxicosis.

**Case 4—W. H., female, aged 17.** No hernia. Admission on April 12, 1944, with a history of acute sudden abdominal pain six days previously. Vomited once. The pain and discomfort varied, but seemed better for three days. Tongue clean. T 99.2°. Tenderness over lower abdomen, right more than left. Rigidity very slight. Diagnosis, appendicitis, much doubt. Not in much pain. On April 13, T 102°. Operation decided, appendicitis. Pain worse. A very massive congested omentum, swollen, bright scarlet

in patches, was found rotated 1 turn anti-clockwise. Much pink fluid in abdomen and much œdema between the layers at the colon attachment. It was untwisted and the vessels palpated. The extreme right edge vessels alone appeared pulseless. About one-fifth of this massive broad, long omentum was removed (Fig 174). The



Fig 174—Case 4. Portion of omentum removed at operation ( $\times 4$ )

intestines and appendix were healthy. Search was made for an intra-abdominal disease, but none found. Investigation and sections of the removed omentum revealed the presence of giant cells and tubercle bacilli. Recovery. A case of acute, secondary, unipolar, intra-abdominal torsion, incomplete, previous œdema due to a tuberculous infection.

### DIAGNOSIS

The condition is rarely diagnosed or even suspected. I am therefore not too ashamed to admit my omission even with experience of four cases. A mention of omental torsion, without conviction, in the second case while under anaesthesia, is the nearest I got to a diagnosis. A great number of abdominal states, from inflammations to tumours, have been selected in error. Over 80 per cent, however, are considered as appendicitis, a much smaller number as perforated ulcers or cholecystitis. Barely a half-dozen are reported correctly diagnosed. From my experience and the result of studying the histories of numerous reported cases, the following points are worthy of notice and should lead to a diagnosis on occasions. The patient, probably aged 20 to 55 years and a male, gives a right-sided abdominal history of pain which gradually gets worse, is often in spasms, and is usually relieved by lying down. Nausea, vomiting, pyrexia, pulse-rate, distension, a white count, a furred tongue, and toxic state are usually conspicuous by their negative value, if positive, are anything but marked features. The patient after admission and in bed nearly always appears well and placid. Tenderness and rigidity on careful palpation again are not impressive. The picture, typically, is one of abdominal pain, gradually

getting worse, it reaches the third day, obviously a case for surgical inquiry, with a lower right quadrant tenderness and little else to show for what ought to be a more advanced abdominal state. There may be a history of undue exertion or accident and a hernial scar or sac may be present. An appendix is suspected and yet one feels inclined to hold one's hand. The palpation of a doughy tumour in the mid-line or to the right, often above the appendix area is a valuable suggestive sign. It must be realized that a rotated omentum varies much in size and the position occupied. In all my four cases the tumour at operation was either in the midline or to the right. The position in bi-polar torsion will obviously be influenced by the site of the lower adhesion. It was the palpation of the tumour in my second case, under anaesthesia, that led to the mention of omental torsion.

Three of my cases were thought to be appendicitis, were doubted, and were not operated on immediately. The fourth was considered an emergency as a perforated ulcer, his agony and rigidity were obviously greatly exaggerated by his nervous thyrotoxic state and led me astray. The prognosis is good in omental torsion. Apart from complications, remote, few have succumbed to the abdominal condition.

### OPERATION

The procedure, as in all cases of torsion, is obvious. The earlier the exploration the fewer the regrets. In such doubtful diagnoses the gridiron incision should not be used. The omentum or a part is almost always removed. In Case 3, for reasons given, I untwisted what was probably an unstrangulated omentum for speed, the patient dying from thyrotoxic effects in a few hours. In Case 4 I believe I was justified in not embarking on the removal of the whole of a huge omentum, though I did not know at operation that it was infected by early tuberculosis. The patient recovered. Thus one case died out of four, and this an omentum which was least affected by strangulation judging by its colour—death was due to thyrotoxic cardiac failure, and in the absence of this complication he would have survived.

The description of the rotated omentum removed, has often been discussed and need not be repeated. It should, however, be examined with care and a note made of any tumour, pedicle formation, fibrosis, or deformity present. The maximum narrowing or pedicle formation has been noted in all parts of the specimens removed. Cases 1 and 2 were constricted above near the colon. Case 3 had a narrowing 3 in. from the lower end just above the consolidation. In Case 4 no narrowing was present. Case 2 was an excellent example of a peg top, the adhesion below being firm, thick, and pointed. There may be few or numerous twists, clockwise or anti-clockwise.

### SUMMARY

1. An account has been given of intra-abdominal torsion of the great omentum, after a survey of the literature.
2. The diagnosis and aetiology have been discussed.

3 Four personal cases have been presented

4 The specimens are illustrated. They were shown at the Section of Surgery, Royal Society of Medicine, on Dec 6, 1944, and have been accepted by the Royal College of Surgeons' Museum, London. They represent intra-abdominal axial rotation of the whole omentum, Case 1 being a primary, Cases 2-4 secondary torsions

5 Among the collection labelled omental torsion, too many cases are being recorded of twists of a small gastro-colic strip or tag. A separate group should include the more important torsion of the whole great omentum

6 An extensive and critical survey of all cases and previous reports up to 1944, brings the total cases to about 190, of which 73 (38 per cent) are idiopathic

For good reasons I have excluded the following from the primary group: Eitel, Noble, Simon, Fuller, D'Allaines and Ruffiac, Reid. Each one at times has been included by some authors and discarded by others

All hernial cases have been excluded and many errors found and corrected in the literature, in bringing the number of cases up to date

Since going to press, Rear-Admiral Cecil P G Wakeley in a personal communication has kindly informed me that he has now dealt with three cases of omental torsion. Two of these cases were published in the *Medical Press and Circular*, 1929, Jan 9

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### PHYSIOLOGICAL GASTRECTOMY

#### THE OPERATION OF LIGATURE OF THE ARTERIES OF THE STOMACH TO RELIEVE HYPERACIDITY AND TO PREVENT RECURRENT ULCERATION AFTER GASTRO-ENTEROSTOMY

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DUE largely to dietetic errors and to deficiency in vitamins, the incidence of duodenal ulcer in South India is extremely high. Thus at the hospital where I have been working for the last twenty-two years, a very large number of operations have been done for this condition, and an unrivalled opportunity has been offered for clinical research as to the after-effects of various methods of treatment

During the twenty-year period, 1924-1944, some 5000 operations for duodenal ulcer were done

at Neyyoor, and 1500 at the branch hospital at Kundara, attached to Neyyoor and run (with many other branches) in conjunction with it. The majority of these cases have been analysed and recorded in the *JOURNAL* (Somervell, 1936 and 1941)

In the latter of these two papers I noted that I had been replacing the extensive operation of partial gastrectomy after the method of Finsterer by the more modest procedure of ligating the arterial supply of the stomach, with good immediate results

in the cutting down of hyperacidity, and therefore probably in the prevention of recurrent (gastro-jejunal) ulceration. At the time of writing the paper in question these cases had not been observed for long, and in fact the operation of vascular ligature had not been done in more than 150 cases. I and my colleagues have now done the operation in nearly 400 cases, of which over 160 cases have had a test-meal done both before and three weeks after operation, and 82 cases have had a late follow-up, including the performance of a fractional test-meal and a thorough clinical examination. It is now nearly eight years since I started doing this operation, and I feel it would be wrong to let more time elapse in reporting the late results of these cases, for in the opinion of my fellow-workers in India, as well as of myself, it has established itself as the treatment of choice in all cases of duodenal ulcer which have been suffering for more than a year and show marked hyperacidity to test-meal examination.

Partial gastrectomy, as we know, cuts down the acidity of the stomach to a remarkable extent, but even in the most skilful hands it is an operation which carries with it a degree of risk, the mortality being in the neighbourhood of 4 per cent. In over 380 cases of arterial ligature with or without gastro-enterostomy done by me and my colleagues, I can trace only 1 death. On this minimum operative risk, as well as its satisfactory late results, I feel that the simpler operation rests its claim to superiority.

In my former paper I described only one method of doing the operation of gastric ligature, but since then various other techniques have been employed, and they, too, have now been examined in the light of both early and late results.

The value of the fractional test-meal in these observations is open to question. It is, with radiography, the only really objective method of assessing results, though nobody knows better than the writer how limited it is in many ways. What we are aiming at is a completely healthy patient, free from pain, able to eat anything, and to live a normal life. He must also continue his health, and not develop any recurrent ulceration of the stoma or of any part of the upper alimentary tract. This much can be ascertained by a full clinical examination. But in comparing methods of technique and alternative operations the test-meal provides an objective and numerical criterion, and, if it is carefully done, with no possibility of the Ryle's tube having reached the duodenum or gone through the stoma, it gives an accurate picture of the acidity of the stomach before and during the taking of a standard meal, which is of real value for purposes of comparison. There is no doubt that hyperacidity is one of the major factors in the aetiology of duodenal ulcer. Among the people of Travancore, where all the work on which this paper is based has been done, duodenal ulcer is extremely common and the average acidity of the population is high. Those patients among our large series who have developed gastrojejunal ulcer have been those with the highest acidity. Of all complications which are likely to follow gastro-enterostomy, recurrent ulceration is the most serious. Therefore it seems reasonable to take the test-meal results as a fair test of the efficacy of a gastric operation, and of its likelihood to be followed by serious trouble.

In the Neyyoor Hospital every gastric case has a fractional test-meal done as a routine procedure, and in deciding on what treatment to adopt, and more particularly what operation to do, in each individual case, I have always allowed the test-meal result to have great influence on the decision. In a case with normal or only slightly increased acidity, and a fasting juice with a total acidity under 60, I consider gastro-jejunosomy to be a sufficient operation—that is, if operation is reckoned to be the treatment of choice for the case. In all cases where the fasting juice is above 60, and especially in those where it continues to be at a high level, the operation has taken the form of gastro-jejunosomy combined with the ligature of the arterial supply of the stomach, as described below. This has now, in my practice, entirely replaced the more formidable gastrectomy, except in cases where there is a gastric ulcer as well as the duodenal one, or there is some suspicion of malignancy.

### THE TECHNIQUE OF THE VARIOUS METHODS OF GASTRO-VASCULAR LIGATURE

**Blood-supply of the Stomach**—The stomach is supplied by the following vessels, as far as its acid-secreting portion is concerned—this portion is, of course, the body of the stomach, for at the pyloric end, as well as in the fundus near the cardiac end, there is little or no secretion of acid (Babkin, 1944) —

*Left gastric artery* Supplies the lesser curvature in its upper three-quarters.

*Splenic artery* (by way of the vasa brevia and left gastro-epiploic) Supplies the posterior part of the body of the stomach, and upper third of the greater curvature.

*Right gastro-epiploic* Supplies the lower two-thirds of the body, and of the greater curvature, and part of the pyloric antrum.

*Right gastric* (from hepatic artery, or proximal portion of gastro-duodenal artery) Supplies the lower quarter of the lesser curvature and the upper part of the pyloric antrum.

From these vessels the actual blood-supply of the stomach is by means of short branches at frequent intervals, most of them being about half an inch apart. The upper part of the lesser curve is, however, supplied by a sheaf of vessels running along the front of the stomach wall close to this curvature and dividing into numerous small branches near the incisura.

**Standard Operation**—The operation of tying the arteries consists in its simplest form—i.e., that which is easiest to do—of firmly ligating, by means of under-running them with a curved needle threaded with fine silk, about five out of every six of the small branches which run from the gastro-epiploic artery to the stomach wall (*Fig 175*). These are tied as far up the greater curvature as can be reached without pulling at the stomach, using the ordinary paramedian incision commonly employed in the operation of gastro-enterostomy. The sheaf of vessels on the lesser curve is ligated *in toto*. The arteries at the pylorus and within an inch of it need not be tied. A hole is made in the mesocolon, as is usually done for a gastro-enterostomy, and the back

of the stomach is inspected. It will be found that some of the arteries along the greater curve have already been tied, but some more will require ligating to bring the number of arteries tied up to approximately five-sixths of the total number. The stomach is gently pulled farther through the mesocolon, and all the arteries that can be reached without undue strain are tied. Unless the patient is under spinal anaesthesia, great care must be taken not to pull at the stomach too strongly. The utmost gentleness must be used throughout. This can be done if the

the vein is also ligated. Similarly, if we wish to deprive a certain portion of the stomach of its blood-supply in order to stop the secretion of acid, it will be more effectively done if the arteries alone, without their veins, are tied.

**Modified Procedure**—In order to do this, another technique was devised, and a series of cases was done in which the arterial supply only of the stomach was dealt with. The four main arteries to the stomach were tied near their origins from the larger vessels, in such a way as not to interfere at all with the return of venous blood from the stomach. In a third series, these four main vessels were tied, with additional ligation of 4 out of every 5 of the smaller branches going to the wall of the stomach itself. The early and later results from these two series of cases were not in any material way different from those obtained by the simpler method outlined above, which we have adopted as the standard method of operation. The reduction in acidity obtained by these three methods is almost exactly the same, and there is therefore no need to perform the more elaborate and more difficult operations, which necessitate considerably more handling of the stomach than is required in the simplest of the three.

## RESULTS

The whole series of cases was also divided into age-groups, those under 30 years and over 40 years of age respectively showing very similar results with one another and with the general series of all cases in which arterial ligation was done.

In a few cases of marked hyperacidity, with symptoms of duodenal ulcer, no ulcer was found at operation. In view, however, of the very high acidity, and as a means also of testing the effect of arterial ligation without gastro-enterostomy, the arteries were tied in this series of 6 cases. Their results are identical with those obtained from the cases in which gastro-jejunostomy was combined with the arterial ligation. This shows that the effect of the operation in lowering acidity is entirely due to the ligation of the arteries, and not to the gastro-enterostomy.

Together with the results of the operations mentioned above, a series of duodenal ulcer cases treated by gastrojejunostomy alone without arterial ligation is divided into two portions, those with high and low acidity respectively before operation. These act also as controls whereby to test the efficacy of the operation of arterial ligation.

In all the cases analysed in this paper, the following tests were done and were recorded as protocols. From them averages were worked out, which are herein tabulated, to save the reader from long lists of figures.

1 Fractional test-meal before operation. Figures recorded here are (a) the total acidity of the fasting juice, and (b) the average of the other readings of total acidity, neglecting the fasting juice and the second reading, which represents the acidity so soon after the ingestion of the meal of gruel as to be valueless for purposes of comparison. The meal used was similar in all cases, consisting of 12 oz of rice gruel ('conjee').

2 Fractional test-meal before discharge from hospital, i.e., about 17 to 20 days after operation.

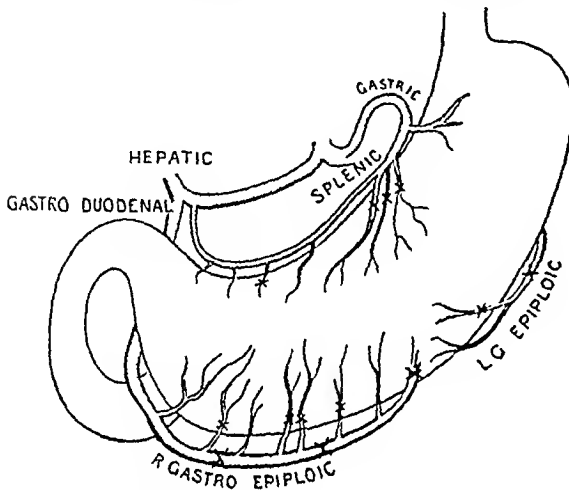


FIG. 175.—Physiological gastrectomy. Diagram showing the arteries tied on the anterior surface of a typical stomach.

incision is adequate, and the wound well retracted as required. Too great a pull on retractors makes for a painful wound; too great a pull on the stomach makes for the much more serious splanchnic shock.

The whole procedure of tying the arteries as described takes about ten minutes or rather less. Gastro-jejunostomy is then performed in such a way as to make the opening in the stomach vertical in direction when the stomach is returned to the abdomen, with its distal end close to the greater curvature. If this is done there will be no tendency to kink the jejunum just below the anastomosis.

The mesocolon is then sewn to the wall of the stomach in such a way that the cut edges are at least an inch away from the anastomosis on all sides, especial care being taken to fasten the anterior end of the hole in the mesocolon firmly to the stomach wall 1 or 2 in. anterior to the anastomosis, to avoid any likelihood of the slipping of the mesocolon over the jejunum and kinking it.

When the arteries are tied in this way the usual effect is an immediate and considerable drop in the acidity of the stomach. A hyperacid stomach becomes one which secretes less than the normal amount of acid. Free HCl is often cut down to *nil* throughout the two or three hours during which the test is done.

Now and then a case is met with in which this operation has no effect at all in cutting down acidity. This must be so, either because an insufficient number of arteries has been tied, or else because with the arteries the veins have, of course, been tied. Every surgeon knows that if a main artery to a limb has to be tied, gangrene is less likely to develop if



3 Fractional test-meal at a later date, varying from 6 months to 6 years after operation

This third series of test-meals was obtained by the only method of follow-up which is likely to be effective in rural India. Every patient concerned was written to, and asked to come and see me at one of several centres, which I visited with a staff of male nurses and a pathologist, stating the dates of my visits at the various centres on the list sent to every patient. Unfortunately this follow-up had to be done in war-time, when transport difficulties were great but in spite of this some 82 cases of arterial ligation, and 8 cases who had had gastrectomy, as well as 40 cases whose operation had been gastrojejunostomy alone, turned up for the examination.

The results of the test-meal examinations done are summarized in the form of averages in the accompanying table, under the various headings mentioned above.

#### Discussion of Results (Fig 176)—

1 Regarding the series tabulated, in which arterial ligation was done as well as gastro-enterostomy, it was known by the results reported in 1941 that the effect of this operation is to cut down acidity to normal levels as evidenced by the test-meals done shortly after the operation. But it was not known to what extent this reduction of acidity

operation, only 1 has returned to our hospital at Neyyoor with a gastrojejunal ulcer. From the last 300 gastrectomy cases done during the same period, a total of 7 have returned with recurrent ulceration. While in the rural districts of South India accurate and complete follow-up is impossible, it can at least

TABLE I—RESULTS

No	OPERATION	BEFORE OPERATION		THREE WEEKS AFTER OPERATION		LATER (1-5 YR)	
		Fasting Juice	Average	Fasting Juice	Average	Fasting Juice	Average
1	L A plus PGE (82 cases)	81.7	65.3	48.0	45	40	41
2	L A only (14 cases)	80	62	46	39	40	44
3	L A plus PGE Main arteries only (14 cases)	86	65	48	44	43	43
4	Gastrectomy (8 cases)	65	64	36	42	75	62
5	PGE only High acidity (29 cases)	77	74	70	55	45	47
6	PGE only Low acidity (11 cases)	47	45	50	51	60	47
7	L A plus PGE under 30 yr of age (26 cases)	80	65	47	44	40	44
8	L A plus PGE over 40 yr of age (22 cases)	75	66	49	48	43	44

Note L A signifies ligation of arteries as described, PGE, posterior gastro-enterostomy

be said that it is very unlikely that there are 6 other cases which have developed ulcers after arterial ligation, and not come to us, while there are none among the gastrectomy cases which have developed ulcers at all. It is therefore almost certain that the operation of arterial ligation offers to the patient a surer safeguard against the serious complication of recurrent ulceration than does any other surgical procedure.

2 With regard to the cases in which the operation of arterial ligation alone has been done, without gastro-enterostomy, the early and late results are exactly similar to those in which gastro-enterostomy was combined with arterial ligation. It is evident, therefore, that the reduction of acidity is caused by the ligation of the arteries, and not by the gastrojejunostomy. This is further evidenced by a comparison with the gastro-enterostomy cases reported in Series 5 of the table.

3 This series shows that where the operative technique consisted of tying the four main arteries only, separate from their veins, the immediate and later results were almost exactly the same as those obtained by performing the simpler technique described as our standard operation. There is, therefore, no point in doing the more difficult operation of ligation of the four arteries, which, at any rate as regards the left gastric artery, involves more manipulation of the stomach than does the tying of the branches to the stomach wall as described.\*

4 I was very surprised when I discovered that the arterial ligation produces a much more satisfactory late result in reduction of acidity than does

\* It has been reported that in one case in which a surgeon tied the left gastric artery, he produced a gangrene of the spleen with fatal results.

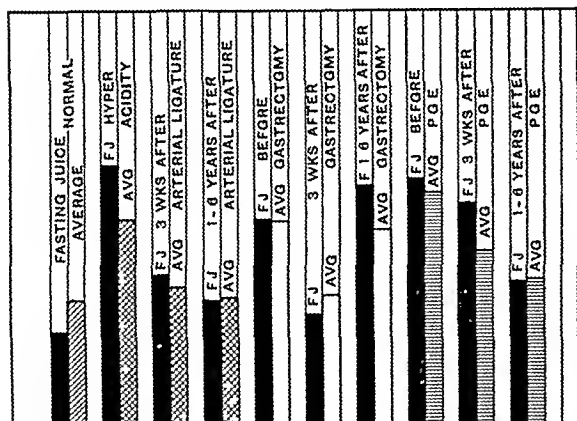


FIG 176—Early and late results of various operations

persisted. Only 10 cases had been tested a year after operation, and these showed that for this period at any rate reduction of acidity actually increased. Now, however, it is found that this lowering of acidity persists for at least five years, and the late results of a much larger series of cases show very satisfactory figures both for the acidity of the fasting juice, and for the average total acidity during the two hours or so after the meal is given. With regard to the incidence of recurrent (gastrojejunal) ulcer, from the total number of cases, nearly 400, in which I and my colleagues have done this



**gastrectomy** This series of cases is only a small one, but seems to show quite definitely that after gastrectomy, which reduces acidity very markedly at first, the strength of the acid in the stomach during digestion, as well as that of the fasting juice, rises to a very high level. In only 1 case of the 8 cases in this series was the reduction in acidity continued for a long period after the operation had been done. In producing permanent reduction of acidity as well as in preventing gastrojejunal ulceration, gastrectomy is not a satisfactory operation, and in addition it is a far more serious one. Arterial ligation seems to be a far more satisfactory procedure, as well as involving negligible operative risk.

5. Gastrojejunostomy alone in highly acid cases is followed eventually by a good reduction in acidity, no doubt because in cases where the pylorus is stenosed it re-establishes the ability of the stomach to empty itself, but its effect in reducing acidity is not established for a year to eighteen months after operation.

6. The paradoxical result in these cases is difficult to explain. The ultimate rise in acidity is probably due to the fact that this series of patients all showed low acidity before operation. That is to say, there was probably an amount of gastritis in these cases sufficient to have produced some hypochlorhydria. The relief of this gastritis by operation seems to have enabled the stomach to recover its power of secreting acid. The same explanation probably holds good in the gastrectomy cases, which show on the average an increase in acidity some years after operation to a level that is higher than that of the acidity before operation.

7 and 8. The results of the two age groups are very similar. Age has therefore little or no effect on the efficacy of the operation of arterial ligation.

Partial gastrectomy, as is well known, cuts down the acidity of the gastric contents as measured by a test-meal to a remarkable extent. But the diminution of acidity is not kept up indefinitely, within a few years the acidity rises to a high level again, and in any case the operation of gastrectomy is one which bears a high rate of risk, for even in good hands the operative mortality is round about 4 per cent. The operation itself is a mere removal of secreting tissue, and is in the category of operations which may be described as mutilations, that is to say, anatomical rather than physiological in its effect. Advance in surgery often rightly consists in the substitution of a minor for a major procedure, but this is only a true advance if the new procedure is at least equally effective in both its immediate and remote effects. As will be seen, this seems to be the case here, for the great reduction of acidity which occurs after the operation of arterial ligation is maintained and even increased for a period of at least five or six years, and the incidence of recurrent ulceration is practically nil. There has been only 1 death in over 380 operation cases, and in only 1 case has a recurrent ulcer been diagnosed—a far smaller proportion than in any series of cases in which any other operation was done, either observed by myself or found in the literature of the subject.

This new operation is based on physiological principles. A brief description of these is appended.

**Physiology of Gastric Acidity**—The glands or crypts of the gastric mucosa are heteroerine in nature, i.e., they contain several different types of cells. Of these the parietal cells, as has long been known, are the ones which secrete HCl.

These cells are present only in the body of the stomach, being practically absent from the cardiac and pyloric ends for a distance of some 4 and 5 cm. from these two openings. Some of the parietal cells reach the lumen of the gland, while some are distant from it, being close to the basement membrane. There are, however, small intercellular canaliculi (Plenk, 1932), through which the secretion of these outer cells reaches the gland lumen (Fig 177). In addition, there are in each parietal cell intracellular canaliculi, through which, apparently, the secretion flows, and in the wall of which it is probably formed (Fig 178). The nucleus of the parietal cell is central, and not, as in most other gastric cells, peripheral. There are few granules, and these are not altered in number during secretion.

The parietal cells and their function are very

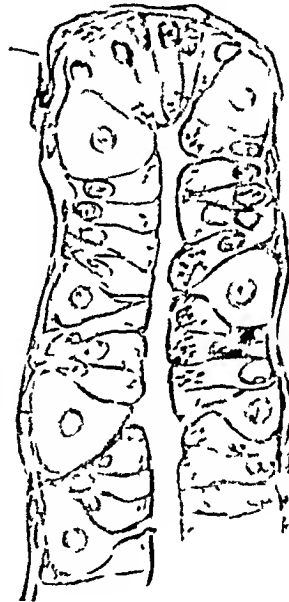


FIG 177—Gastric tubule (After Plenk)

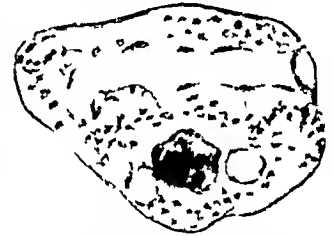


FIG 178—Capillaries in a parietal cell (Bensley's copper hæmatoxylin)

intimately bound up with the vascular system. In the regions where they are fewest, the blood supply of the stomach is not so rich as in other parts, and the capillaries are smallest (Hofmann and Nather, 1921). Moreover, there is an intimate correspondence between the physical chemistry of the blood and the gastric secretion. The osmotic pressure of the blood and of the gastric juice are always identical (Gillman and Cowgill, 1933). Artificial variations in the osmotic pressure of the blood are immediately followed by similar variations in that of the gastric juice. Moreover, the total chloride content of the gastric juice is always equal to the ionic content (total) of the blood. Variations in blood electrolytes are similarly followed by corresponding variations in gastric chlorine. Gillman maintains that chlorine is filtered from the blood by the outer membrane of the parietal cell, which is permeable to chlorine and hydrogen in ionic form, that HCl is secreted by the parietal cells in a diluted condition, of pH 6.7, and the water from it is absorbed by the cells lining the lumen of the gland, until osmotic equilibrium with the blood is established. The Cl ion, once it

is secreted, is unable to return to the blood-stream, as these cells are impermeable to it. After concentration, the pH rises to the neighbourhood of 1.0. Bensley and Hoerr (1936) consider that the parietal cells secrete a precursor of HCl in the form of a protein hydrochloride, which is later hydrolysed to form HCl. But no protein as such is excreted by the parietal cells, the secretion of which is negative to Millon's and other protein tests.

Hollander (1943) considers that the low acidity found in the parietal cells is due to the fact that the actual secretion of the HCl is done in the wall itself of the canaliculus, in which situation chlorine is found at its maximum (Collip, 1920). The residual alkali in the cell due to the escape of H ions is neutralized by intracellular buffers, and goes, with water, through the basement membrane.

From the series of test-meal results quoted in this paper, it is evident that a decrease in the blood-supply of the stomach at once causes a great decrease in the acidity of the gastric juice, both fasting juice and the juice secreted during digestion being equally profoundly affected in hyper-acid cases, and usually being brought down to almost exactly the normal for a healthy stomach.

Is it possible either to explain this effect by the generally accepted theories of the physiology of secretion of the gastric juice, or to use these observations further to extend our knowledge of these processes?

There are two ways in which the effect may be produced. A hyperacid stomach may owe its excess of acidity to an overaction of the parietal cells, in response to a chronic irritation, or to an overaction of the cells lining the lumen of the gland, from a similar cause, which results in their absorbing water from the dilute acid in excess, leaving the juice in the end with a high concentration of HCl.

The effect of depriving the gastric mucosa of a large proportion of its blood-supply may therefore be either to cause the parietal cells to secrete less acid, and possibly to cause many of these cells to die; or, on the other hand, to limit the reabsorption of water on the part of the cells lining the crypts.

It would be extremely interesting to take a section of a piece of the mucosa from the stomach of a patient who had had the operation of arterial ligation some time before, and in whom a marked reduction of acidity had taken place. Unfortunately, in the one patient of our whole series who re-submitted himself for operation for recurrent ulceration, there had been no appreciable reduction in acidity, owing, no doubt, to an insufficient number of arteries having been tied. Thus, we will have to await another case of recurrence, which seems unlikely to come our way for some time. In the meantime I am doing some experimental work, which I hope will lead eventually to the obtaining of the information we require. Histological changes will be looked for, and an investigation made to ascertain whether there is a material change in the total secretion in quantity as well as in quality. These will be reported later.

It has been questioned whether the effect of tying the gastric arteries produces its effect by the simultaneous interference with the nervous mechanism of gastric secretion.

The sympathetic nerves, or most of them, enter the stomach along the gastric arteries. Ligation of the arteries might, therefore, produce a stoppage of their action. But they would almost certainly regenerate rapidly, as they do after peri-arterial sympathectomy in other parts. The fact that the lowering of acidity after the operation just described is permanent in nearly every case leads one to the belief that the essential of the operation is the cutting-off of the blood-supply, and has little or nothing to do with the nerves. Moreover, the sympathetic nerves have very little influence on the secretion of acid, which is the function almost exclusively of the vagus nerves.

The course of the vagi is entirely different from that of the sympathetic nerves. The vagi cannot be affected by the operation described, although it is well known that division of both of them produces inability to secrete any hydrochloric acid.

The reason why section of the vagi was never tried by my colleagues or myself in order to diminish acidity is that the results are too uncertain. On the one hand, the section of one vagus has only a transient effect, on the other, section of both vagi would in theory produce a total cessation of acid secretion. If the nerves regenerated, this would be only temporary, if they did not, it might be permanent. In either case, it would seem that section of both vagi is undesirable. (See Babkin, *op cit*, pp 198-264.)

In the meantime the useful and practical fact is known that the result of the ligation operation is permanent in the vast majority of cases, at any rate for a number of years. It is therefore felt that the report of the cases on which this paper is based should not be delayed until the physiological findings are completed, for it is an operation which may be of great benefit to a wide circle of sufferers. It may, in fact, prove to be the answer to the vexed question as to what is the correct treatment (Roy Soc Med, 1944) of duodenal ulcer with hyperacidity, in which medical treatment is so tiresome and so often unsuccessful, and in which the severe operation of gastrectomy is too risky, while the safer operation of gastro-enterostomy is apt in some 6 per cent of cases to be followed by recurrent ulcer at the anastomosis or elsewhere. It is the belief of my co-workers and myself that the operation as described does, in fact, settle this long-standing problem more satisfactorily than has hitherto been done.

## SUMMARY

The operation of ligation of a large proportion of the arteries supplying the stomach is described. This operation leads to the cutting down of hyperacidity to normal levels, and sometimes below. It is hardly ever followed by recurrent ulceration, and the reduction of acidity is permanent, at least for five or six years, and in this respect is superior to that obtained by gastrectomy.

It is believed that this is the operation of choice in all cases of duodenal ulcer with marked hyperacidity, and it can easily be combined with gastro-enterostomy, without raising the mortality of that operation.

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## THORACO-ABDOMINAL WOUNDS IN WAR

By GUY BLACKBURN, MBE, MAJOR, RAMC  
AND A L D'ABREU, OBE, LT-COL, RAMC

THORACO-ABDOMINAL wounds had an evil reputation in the Great War of 1914-8, and this has been maintained in the present conflict as shown by Gordon-Taylor's Bradshaw Lecture (1942) recording a mortality of 37 per cent, more recent figures (1944) of 44.5 per cent from the same author, and 51 per cent in a series of 292 cases from Normandy would appear to support that view. This present analysis is a survey of 126 cases from Forward areas and 74 from the Surgical Division of a Base hospital in Italy in 1943-4.

Of the 126 cases dealt with at Forward operating centres, one of us (G. B.) operated on 32—in a total of 1500 cases, with 81 penetrating wounds of the chest. There were 105 abdominal casualties in all and the percentage of thoraco-abdominal wounds (30.5 per cent) in these is misleading. Selection of cases for special centres, where much of the work was done, is probably the explanation of a figure differing so strikingly from the 12.7 per cent of Gordon-Taylor (1942), 12 per cent of Cuthbert Wallace (1918), and 11 per cent of Jolly (the Spanish War).

## MORTALITY

Of the 126 cases, 46 died (36.5 per cent), and of the 74 cases reaching the Base only 3 proved fatal. This represents an all-in mortality-rate for thoraco-abdominal wounds of 38.9 per cent. It should be pointed out, however, that no case treated conservatively has been included in this series and there were 20 apart from the 126 which came to operation. The inclusion of these would lower the mortality-rate to 33.8 per cent, for recovery occurred in all.

## TYPES OF WOUND

The distinction between thoraco-abdominal and abdomino-thoracic wounds is important, and the great majority belong to the first group—with an entry wound in the chest and foreign body or wound of exit below the diaphragm. They are clearly more favourable than the opposite type and less likely to require laparotomy. Wounds of the right side tend especially to belong to this category, and if the liver is the sole abdominal viscus injured, laparotomy need not, and indeed should not, be undertaken. Of the 126 cases cited, 65 were right-sided and 8 only had an associated hollow viscus lesion, 22 of the 65 (33.8 per cent) died. On the

left side, on the other hand, 30 of 61 cases had a hollow viscus lesion and there were 24 deaths (39.3 per cent). The presence of solid as opposed to hollow viscus injury is in fact prognostically more favourable.

## TYPE OF OPERATION

Strong preference for thoracotomy for a thoraco-abdominal wound is the natural inference, when the damage below the diaphragm is so often such that no operative interference is required. Trans-diaphragmatic manœuvres, moreover, are often no more difficult than intraperitoneal through a separate laparotomy incision. Splenectomy is an admirable example, and, in our view, is even easier from above than below the diaphragm. Repair of the stomach, colon, or upper jejunum is likewise not difficult by this route, and the rarity of lower abdominal visceral injury in thoraco-abdominal wounds is too well known to require reiteration. If laparotomy is required, as a rule it is to explore the upper abdomen, and a Kocher's incision has been found to give excellent access. Post-operative convalescence has been smoother with this than with the paramedian wound where laparotomy can be avoided altogether, however, results are better still.

The type of thoracic operation is also subject to variation, most British surgeons being content with rib resection and closure of the pleura after repair of the diaphragm. Blood and blood-clot are, of course, removed from the pleura (which is closed without drainage) and a laceration of the lung may occasionally require suture. In the American Army, on the other hand, a more extensive operation is often done for right thoraco-abdominal wounds, involving the right leaf of the diaphragm and liver. The former is sutured and the retrohepatic area is drained after resection of the 11th and 12th ribs. Colonel Churchill (Consulting Surgeon, American Army) has stated that right-sided subphrenic abscess is common after liver wounds and bile empyema rare. In our series of 74 cases, by contrast, there has been but one subphrenic abscess after a liver wound and seven bile empyemata. The difference may well be due to the different techniques employed.

Of the 74 cases arriving at a Base hospital, 23 had already had a laparotomy, 18 a thoracotomy, and only 2 a laparotomy and thoracotomy. The great majority of the cases under review were operated on at a 'level' where X rays were not available.

(Field Dressing Stations or Field Ambulances), but adequate operative treatment can go far to neutralize this apparent disadvantage. In the post-operative period, reliance should be placed on the aspirating needle in the absence of the radiograph, or in addition to the latter where X-ray facilities are available. Aspiration of blood and/or air is invariably required in these cases and is better done early and often than late or never. Here, of course, the experience of a physician, and particularly one skilled at aspiration, is of inestimable value, and the after-care of these cases is a combined problem. Breathing exercises and blood transfusion (at the fourth or fifth day) are among the points to which special attention has been paid. Complications, as will be shown later, are more frequent above the diaphragm, and undue attention is too often paid to the abdominal wound to the detriment of the thoracic lesion. A common example is rule-of-thumb venoclysis with its attendant danger of pulmonary oedema and bronchopneumonia.

A word may finally be included about the non-operative treatment of thoraco-abdominal injuries. This has a place, especially on the right side, but certainty of diagnosis is difficult, if not impossible, without radiography. A wound may, in fact, be labelled thoraco-abdominal only when (1) A foreign body (with an entry wound in the chest) can be demonstrated below the diaphragm (2) Hæmaturia is combined with a hæmo- or hæmopneumothorax (3) The presence of a pleuro-biliary fistula is proved by paracentesis thoracis.

### THE WOUND IN THE DIAPHRAGM

Immediate repair of the diaphragmatic wound does not as a rule present any difficulty. It is infinitely easier from above than below and, performed in two layers, gives satisfactory results. In most cases the lesion is too small to require repair or repair is thought unnecessary. This is particularly the case on the right side, where diaphragmatic hernia is not a danger. Among the 74 cases arriving at the Base, there were 2 of diaphragmatic hernia, but neither of these had had a laparotomy or thoracotomy. One had a coincident empyema and died after thoracotomy, the other revealed an extensive avulsion of the diaphragm from its anterior and lateral parietal attachments, and the free opening into the peritoneal cavity was at least 10 in long. The defect was repaired (A. L. d'A.) by suturing the torn diaphragm to the chest wall above the line of its natural attachment and a successful closure obtained. Radiological confirmation five weeks after operation showed the division of cœlom from pleural cavity at a high level.

Impaired mobility of the diaphragm, which remains high long after operation in this type of wound, is a matter of common experience and should not give rise to concern in the absence of other signs and symptoms. It is also a feature of cases of simple hæmothorax.

### COMPLICATIONS

Although the mortality-rate in those patients who survive the initial wounding and operative treatment is low, the morbidity-rate is high. The

complications in the series of 74 cases quoted were —

	Cases
Hæmothorax	28
Atelectasis	15
Subphrenic abscess	12 { (6 with coincident empyema)
Empyema	11
Empyema with pleuro-biliary fistula	7
Lung abscess	2
Liver Abscess	2

### Hæmothorax, Atelectasis, and Lung Abscess

—The management of the hæmothorax is no different from that in a simple thoracic wound. Re-expansion of atelectatic lobes after postural drainage and MacMahon's breathing exercises is the rule and a course of sulphadiazine is often of value in reducing pyrexia, where progress is slow. Both the lung abscesses recorded in the table above resolved without operation, and experience has led us to believe that a course of parenteral penicillin, such as these two cases were given, is of the greatest value.

**Empyema** —Perhaps the most significant feature is the high incidence of empyema (24 per cent), but by no means all of them were due to infection of a hæmothorax. A considerable proportion follow lower lobe collapses, associated with serous effusions that become purulent. In thoraco-abdominal wounds, therefore, a constant watch is essential and paracentesis thoracis is indicated, if the signs of effusion appear clinically or radiologically. Of the 18 treated in this series all made satisfactory recoveries, except one accompanying a large diaphragmatic hernia. The coexistence of subphrenic abscess and empyema is notable, and the injection of lipiodol followed by radiography is a valuable help in diagnosis.

**Pleuro-biliary Fistula** —The diagnosis is easily made by pathological examination of fluid obtained by aspiration from the pleural cavity. The 7 cases quoted did well, but all developed empyemata—an interesting observation, when it is remembered that bile-salts were once used as a form of treatment for pleural empyema. They should be drained early, as loculation is likely if this measure is delayed. Re-expansion was rapid in all cases and disappearance of bile more rapid still. One patient had a secondary hæmorrhage from his liver, but survived after re-operation.

**Subphrenic Abscess** —A total of 12 cases occurred, situated as follows —

	Cases
Left posterior subphrenic space	6
Right posterior subphrenic space	1
Left anterior subphrenic space	2
Right anterior subphrenic space	3

Significant diagnostic features were hectic fever with its constitutional malaise, high leucocytosis, local tenderness and swelling, restricted rib movements, a diaphragm invisible radiologically with a fluid level beneath it, and an overlying sympathetic pleural effusion. Six cases had a coincident empyema and, in 2 of them, lipiodol demonstrated the two cavities and their communication. In the other 4, pus was seen to be coming up through the diaphragm at the operation for drainage of the empyema. Drainage of the subphrenic abscess was then carried out at the end of the chest intervention. All the

subphrenic abscesses were drained, the Ochsner route (resection of the 11th and/or 12th ribs) being most satisfactory for those posteriorly placed. Two right anterior abscesses were drained by anterior rib resection and extrapleural diaphragmatic incision, and the remainder were approached through abdominal incisions. All the patients recovered, except one Yugoslav woman soldier with a total right pyopneumothorax, a liver abscess, and a right intraperitoneal subphrenic abscess. She died of liver failure three months after admission.

### THE PROBLEM OF RETAINED MISSILES

The causative missile is rarely seen during operations for thoraco-abdominal injuries, but should of course be removed if it comes easily to hand. In those with retained foreign bodies, the liver is a common site, but the fate of retained missiles is difficult to ascertain in this organ. No authoritative account has yet appeared in the literature, and it may be mere wishful thinking to suggest that they do not often cause mischief. Such is not invariably the case when missiles have been removed, as the following example shows —

A man with a large sucking right thoraco-abdominal wound was operated on at a Field Ambulance twelve hours after injury. A very severe wound of the right ankle-joint with vascular injury required below-knee amputation, which was preceded by rib resection and closure of the chest wound, with transdiaphragmatic removal of a large metal fragment (2 in. x 2 in.) from the liver. Five days later the patient appeared to be doing well and aspiration of the chest on two occasions had revealed only a moderate amount of blood. Signs of septicaemia then appeared, from which he died on the eleventh day. Autopsy showed the amputation stump and pleural cavity to be clean, but the site of the foreign body in the liver was by now an abscess—with pyæmic abscesses in lungs and kidneys to confirm the diagnosis.

Missiles in the subphrenic region are also of interest and have been removed from beneath each diaphragmatic leaf. Furthermore, two have been removed from the perinephric space. The two truly subphrenic missiles illustrate many points of interest in connexion with these cases —

1 Shell wound, abdomen, jejunal resection, right pleural empyema, right subphrenic abscess, recovery —

A gunner was admitted to a Base Hospital four weeks after operation at a Field Dressing Station (Major F E Wheeler, R.A.M.C.). A grossly lacerated portion of jejunum was resected and progress was satisfactory until a pleural empyema developed, requiring intercostal drainage. A radiograph disclosed a shell fragment just below the cupola of the right diaphragm and lipiodol into the intercostal tube showed a track leading through a small diaphragmatic hole into a cavity between liver and diaphragm. From this cavity a track led to the shell fragment. At operation, resection of the 9th rib in the mid-axillary line showed the costophrenic sinus to be obliterated by adhesions. Incision of the diaphragm revealed an abscess cavity containing the fragment, which was removed. Recovery was uneventful. It seems clear that the missile, after traversing the abdomen, lodged in the diaphragm, causing a pleural empyema and then dropped back into an associated subphrenic abscess.

2 M.G. bullet wound, left anterior intraperitoneal subphrenic abscess, recovery —

A commando soldier was shot through the left lower chest at close range. Ten days later he had left upper abdominal pain and pain referred to the left shoulder tip. There was a minimal left pleural effusion. Radiology disclosed a bullet lying below the centre of the left dome of the diaphragm. A left transthoracic approach was employed through the bed of the resected 7th rib. The left lower lobe was adherent to the diaphragm and separation exposed an inflamed area of that structure. This was incised and the bullet removed from a small abscess cavity between it and the left lobe of the liver. This abscess was carefully mopped out and sulphamide powder left in it, the diaphragm and chest were then sutured without drainage. A left pleural effusion required several post-operative aspirations, but recovery was satisfactory.

Foreign bodies in thoracospinal wounds can likewise give rise to trouble, especially when there is bone damage to the vertebral column, but complications such as this are outside the scope of this paper. So, too, are the associated wounds, which so often determine the issue.

### SUMMARY AND CONCLUSIONS

1 Of 126 thoraco-abdominal wounds treated in Forward areas, 46 proved fatal (36.5 per cent).

2 Of 74 patients with thoraco-abdominal injuries arriving at a Base Hospital from Forward areas only 3 died.

3 The all-in mortality-rate of thoraco-abdominal wounds treated by surgery is 38.9 per cent.

4 Thoraco-abdominal wounds are less serious than abdomino-thoracic.

5 Solid viscus injury in the abdomen in these cases is more frequent than that of hollow viscera and is prognostically less serious.

6 Laparotomy should be avoided, where possible, in favour of thoracotomy and the transdiaphragmatic approach to the abdomen. If laparotomy be required, a Kocher's incision gave good results in our hands.

7 Conservative treatment in cases properly selected and controlled gives excellent results, e.g., as in many cases of retained liver missiles without evidence of other intraperitoneal mischief.

8 Diaphragmatic hernia is uncommon as a sequel of thoraco-abdominal wounds.

9 The complications most commonly encountered are hæmorrhage, atelectasis, empyema, and subphrenic abscess.

10 Pleuro-biliary fistula with empyema occurred in 7 of 74 cases. All recovered.

11 The fate of retained missiles, especially in the liver, is difficult to assess.

We are indebted to Majors F E Wheeler, E H C Harper, H G Estcourt, and C G Rob for their figures of operations in Forward areas, and to Major J W Litchfield, Medical Specialist, and Major C J Hodson, Radiologist, for their co-operation in the management of these patients at a Base Hospital.

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## PRINCIPLES IN EARLY RECONSTRUCTIVE SURGERY OF SEVERE THERMAL BURNS OF THE HANDS

By BYRON SMITH, MAJOR, M C, U S ARMY, CARLETON CORNELL, MAJOR, M C, U S ARMY, AND CHARLES L. NEILL, MAJOR, M C, U S ARMY

THE frequent disabilities and deformities resulting from the improper treatment of burns of the hands makes a satisfactory method of therapy worthy of reiteration and discussion. It is not our intention to claim originality or denounce other forms of treatment. The results obtained by the method of therapy described in this paper are attributed to the observation of numerous details.

A large number of war-time burns occur as a result of exposure to gasoline flames in aircraft, mechanized equipment, and field ranges. Characteristically, there is thermal destruction of the tissues, of the lips, nose, upper face, eyelids, brows, forehead, ears, dorsum of the hands, and encircling burns about the wrists. Unlike burns encountered in civilian life, the rapidity and depth of tissue destruction in a burning aircraft is often influenced by the presence of oxygen, as well as high octane gasoline. The majority of aircraft burns occurs in take-off and landing accidents.

Prevention and minimization rests in the proper wearing of protective fire-resisting headgear and gloves. Although the operation of military equipment is rendered more difficult by the employment of fire-resisting apparel, the insurance offered by the burden is worthy of consideration.

Since modern literature is flooded with the initial systemic, supportive treatment of early burns, its importance requires no emphasis. Transportation of the burn casualty to a hospital equipped for definitive treatment should be accomplished immediately. After seven hours, and often sooner, the development of secondary shock renders transportation hazardous.

Meticulous care should be taken to prevent infection. Initial success depends upon protection of the wounds from contamination by organisms harboured in and about the orifices of the body of the patient and attendants. Relaxation of aseptic technique is inexcusable. Initial conservation debridement is of value if strict surgical precautions are observed. Medical attendants and the patients should always wear a cap and mask when the wounds are exposed. Floor dust in the atmosphere from recent sweeping constitutes a frequent source of wound contamination. Use of so-called 'clean' bandage scissors may inoculate pathogens. The most common organisms found in infected thermal burns are hæmolytic streptococci, hæmolytic staphylococci, *B. pyocyaneus*, *B. coli*, and *B. proteus*.

The general condition of the casualty during the first three days often demands immobilization of the hands. It is during this time that œdema develops in all of the soft tissues of the hands and fingers. If pressure dressings are used they should not be tight enough to interfere with circulation in the hand and fingers. To combat œdema, the hands should be elevated high above the level of the heart. Proper initial elevation is an important

prerequisite to good treatment. The ideal position of the hand is mid-flexion of the fingers and 45° extension of the wrists, with the arms suspended by means of two padded full-length arm splints, flexed 20° to the elbow for comfort. It is a common error to allow the patient to rest the hands on the chest with the wrists flexed and the fingers extended (Figs 179, 180). Support of the hands and arms



FIG 179—Correct posture of the hands in an elevated position suspended from an orthopaedic frame. Mosquito bar is draped over the frame to protect the patient from fly and maggot infestation of the burns.

on pillows may be utilized. The most effective means of elevation is suspension from an orthopaedic frame or an overhead beam. Elevation is continued after exercises have been started.

As early as three days after the injury active motion is instituted. The technique of motion entails the use of an arm tub with submerging exercises under the direction of an experienced and qualified physiotherapist. The immersion bath consists of tepid sterile physiological saline solution. Encouragement and psychotherapeutic suggestion is given by all attendants dealing with the patient. The sterile gloved hand of the physiotherapist may be used to demonstrate the amount of passive motion the patient should command by active muscular activity. Exercise in the bath is well tolerated for one half hour three times daily. At one period each day the dressings are floated off to permit exercises without the limiting effect of bandages. The digits are bandaged independently to prevent webbing and to allow greater freedom of movement. Deep



third-degree burns are not incompatible with complete flexion of the fingers

The most common result of delayed early motion is an extension deformity of the hand. The wrist



FIG 180—Improper position of the hands on the chest with fingers extended and wrists flexed. The fingers are bandaged independently to allow motion and prevent webbing

is held in flexion and motion of the fingers is executed only in the metacarpophalangeal joints. The fourth and fifth digits tend to develop a deformity characterized by hyperextension of the proximal phalanges and acute flexion of the distal phalanges



FIG 181—Case E B. First- and second-degree gasoline burns of the dorsum of the hand and fingers supported on a sterile debridement tray. Treated with vaseline gauze and exercises. Complete restoration in three weeks

It is difficult to determine the depth of a severe burn until demarcation of slough is established (Figs 181, 182). The type of dressing employed in selected with the desire to promote early separation of slough and to prepare the wound for grafting. As demarcation takes place the slough is excised by delicate meticulous dissection under pentothal anaesthesia. If extension of the digits has superseded

the desired degree of flexion, the fingers are gently placed and dressed in acute flexion for twenty-four hours. Forceful manipulation of the digits in an attempt to break adhesions should not be done. Resulting oedema, hæmorrhage, and destruction of peri-articular tissues may initiate an irreparable loss of function. Granulations are grey and covered with a slimy mucopurulent discharge following the prolonged use of vaseline gauze dressings. The granulating areas become pink, friable, and bleed easily when sulphanilamide crystals and saline dressings are substituted. Saline dressings prepare the wound for grafting in twenty-four to forty-eight hours.

Scar tissue forms in the base of the granulating bed in an early phase of the reparative process and continues until epithelialization is complete. It has



FIG 182—Case L M. Third-degree gasoline burns of the dorsum of the hand and fingers prior to separation and excision of the slough

been shown that organization and fibrosis are sequelæ of persistent early oedema. Fibroblastic organization and cicatrization is anticipated as early as twelve days. Surgical epithelialization is the means of arresting the process of scar tissue formation. Decrease in local pain and diminution of the exudation from the wound parallels a favourable turn in the tide of infection. Although it is considered scientific to use bacteriological studies as a gauge in the determination of therapy, it may be ignored as a factor in the time to graft the burned hand. Regardless of the bacterial flora, early grafting of the wound is imperative.

Laboratory determination of total blood-proteins, albumin, globulin ration, hæmoglobin, and red-cell count are taken as an index for the administration of blood and plasma in preparation for operations.

### ANÆSTHESIA

Pre-operative medication is individualized. Although the type of anaesthesia employed is occasionally dictated by the systemic condition of the patient, it is preferable to employ inhalation anaesthesia. Light anaesthesia decreases the tendency to shock. Unless muscle relaxation is required for technical reasons, deep anaesthesia in the burned individual is undesirable. The anaesthetic time is reduced when a separate surgical team simultaneously



operates on each burned area. If burns about the head are being dressed or grafted at the same time, intratracheal anaesthesia offers less technical interference in the operative fields, maintains a patent airway, and facilitates removal of mucus from the trachea. Packing of the nose and mouth prevents the aspiration of irrigating solutions and blood. Closed-system either oxygen or ether administered by a Flagg can is a simple efficient method. Novocain block and pentothal anaesthesia may be necessary in selected cases, but is not usually recommended for the procedure. During the anaesthetic the administration of fluids, plasma, or blood is frequently necessary.

### SURGICAL TECHNIQUE

We have found that grafts will grow as early as eleven days following thermal destruction of the dermis. Fractures interfere with early activity, but should not prevent early grafting. Compound fractures, open joints, exposed tendons, or bone surfaces have not been a contra-indication to early grafting. Unreasonable as it may seem, we have succeeded in closing open joint spaces and covering bones and tendons with viable split-thickness grafts. Failure of the graft locally over exposed tendons of deficient viability has been followed by rapid proliferation of epithelium from the adjacent graft margin.

In a wound ready for grafting one may observe thin shiny labile epithelium around the margins of the wound as well as small islands of feeble epithelium. Such tissue is of poor quality and is easily dislodged from its underlying base of cicatrix. The burned area is thoroughly scrubbed with neutral soap on a gauze sponge and irrigated with sterile water. The mechanical action of cleansing removes much of the thin, poorly organized epithelium. A blood-pressure cuff applied to the upper arm is used to control bleeding. A sharp Ferris Smith blade provides a useful instrument for the radical excision of granulation tissue and slough. The wound is gradually sliced down until a smooth firm base is encountered. All granulations, islands of sparse epithelium, and skin margins are included in the excision (*Figs 183-186*). Areas not amenable to slicing may be prepared with a mastoid curette. Large sheets of split-thickness graft are required to cover the hand. These are obtained in the desired uniformity by means of a Padgett dermatome. Grafts for the dorsum of the hand cut  $\frac{1}{16}$  in in thickness have offered the best technical and cosmetic qualities.

It is desirable to take skin from an area which will cause the patient as little post-operative discomfort as possible. The available skin from which the graft is cut may be limited by the distribution of burns over the body. Thick grafts should not be taken from the thin skin covering the adductor surface of the thigh or medial aspect of the arm. Thick split grafts from the anterior, lateral, and posterior surfaces of the thigh are well tolerated. It is technically less difficult to secure a full drum of skin from the average thigh in the horizontal meridian than it is by cutting in the longitudinal axis of the thigh, also it is more economical if the

available healthy skin is limited. The abdomen is a useful donor area. When the chest is selected as a donor site, injury to the nipples is avoided by careful observation of the blade in action. If the drum is destined to pass over the breast, the nipple may be protected by the local application of vaseline to the areola after the surrounding skin has been painted with rubber cement. Emaciation and prominent ribs offer technical difficulties which are easily eliminated by a preliminary subcutaneous injection of saline beneath the depressed areas of skin. In elevating the skin over the depressions of the chest with saline, care should be taken to avoid entering the pleura. The skin of the back and buttocks may be used as a donor site if necessary. Due to the fact that most burned patients prefer to rest in the supine position, an attempt to avoid the back as a donor site is a humane gesture by the surgeon. In our experience it is advantageous to leave the distal end of the graft attached to the adjacent normal skin until the drum is peeled loose from the graft. Not only does this manoeuvre strip the rubber from the surface of the graft, but saves time and unnecessary manipulation of the graft in mid air.

Usually a drum and a half of skin will cover the dorsum of the hand, fingers, and thumb. Sulphanilamide crystals dusted on the surface of the graft will mechanically inactivate the adhesive qualities of residual rubber cement.

The raw surface of the skin-graft is covered by tissue fluid which contains valuable haemostatic agents. To preserve this haemostatic property the graft should neither be sponged nor washed with saline, but placed directly on the surface of the prepared recipient bed. Gentle pressure applied against the graft will stop the oozing of blood. After pressure for a few minutes persistent bleeders may be controlled by clamping and twisting. Ligatures and haemostatic sutures introduce undesirable foreign material beneath the graft and should be avoided if haemostasis is obtained without them. Re-application of the tourniquet pressure cuff may be occasionally required. A tourniquet should not be applied for more than twenty minutes without allowing an interval to resume circulation in the extremity. A twenty-minute period of application of the tourniquet is considered maximum in view of the circulatory changes which are already present as a result of the burn. To obtain the best healing results the graft is stretched uniformly, and as tightly as possible. Fixation is attained by interrupted sutures. To maintain tension it is necessary to suture the graft to healthy skin. Excessive overlapping of graft is trimmed close to the sutures to prevent collection of fluid under the non-viable overhanging graft margin. Two types of sutures have been used. Medium dermal nylon 000, and 000 braided silk. It is felt that the only necessary feature of the suture material is strength sufficient to maintain tension in the graft. An additional advantage in the use of heavy materials is the ease with which the sutures may be placed and tied. Pattern cutting is not considered necessary. When the graft is stretched into its taut position the finger extensions are split away from the graft down to the web. Perforation of the graft is not done as

the technique of tension and hæmostatic action of the graft itself has been found sufficient to prevent the accumulation of serum and blood. Penicillin, small amounts of sulphanilamide, or a plasma coagulum did not seem to hinder or aid in our results. An

when the odour is offensive. The vaseline gauze usually becomes adherent to the donor wound and should not be removed until it is spontaneously separates itself. Healing of the donor site usually requires about ten days.



FIG 183—Case J V. Excision of slough, granulation tissue, and labile epithelium by sharp dissection.



FIG 184—Case L M. Recipient bed after surgical preparation.



FIG 185—Case L M. Split-thickness graft  $\frac{1}{100}$  in in thickness sutured into position.



FIG 186—Case J L. Traction sutures through the finger nails to aid in the position of acute flexion during the immediate post-operative period.

ideal storage place for the graft before it is applied is the donor wound itself, rather than in a saline sponge on the instrument table. The dressing of the applied graft should be one which will not become adherent. Rubber cement remaining on the surface of the graft is an undesirable feature. Xeroform gauze or sulphanilamide crystals with dry gauze minimizes sticking. Cotton batting is applied and the hand wrapped in a pressure elastic bandage with the fingers acutely flexed. The wrist is cocked in extension on a padded basswood splint. The graft is allowed to remain dry twenty-four hours before saturating continuously with saline from a sterile syringe.

The dressing of the donor area consists of a double layer of vaseline gauze or tulle gras, over which is placed a thin layer of sterile gauze and an abdominal pad. The pad is supported in position by elastic bandage, elastoplast, or wide strips of adhesive plaster. The outer pad may be replaced

## POST-OPERATIVE CARE

The total period of splinting and post-operative elevation is five days. Dressings are washed away in an arm tub bath on the fifth day. Meticulous care and abundant saturation is required to prevent the separation of the graft from its recently acquired bed. Cocoa butter is applied to the surface of the graft and further dressings are eliminated. During the daytime while the patient is awake the graft needs no protection other than good co-operation of the patient. At night the graft is covered with a well-padded loose dressing to protect the hand from trauma during sleep. The submersion baths are resumed three times a day. Elevation is continued when the hand is at rest. The rehabilitation exercises are directed towards flexion and extension.

The ease with which the motion of adduction of the thumb to the extended fingers is performed cannot be selected as a criterion of good function.

Restoration of normal function in a hand is dependent upon a wide range of motion in the interphalangeal joints. Unless the patient is specifically instructed, a tendency to substitute motion in the metacarpophalangeal joints for flexion and extension of the interphalangeal joints is outstanding. Neglect of early full motion of the interphalangeal joints is an open invitation to permanent dysfunction and deformity. Encouragement and constant attention is demanded if good functional results are expected.

Elevated healed edges around the graft at the junction with normal skin is only of temporary cosmetic concern. Spontaneous levelling of the

4 Initial treatment is directed toward prevention of infection and restoration of function

5 Infection and exposed tendons and bones do not contra-indicate early grafting

6 Radical excision of slough, granulation tissue, and poorly developed epithelium prepare the recipient surface for a split-thickness graft

7 The graft is sutured in place under the tension of normal skin

8 Post-operatively, dressings and splints are removed on the fifth day

9 Rehabilitation exercises are resumed until maximum functional activity is accomplished

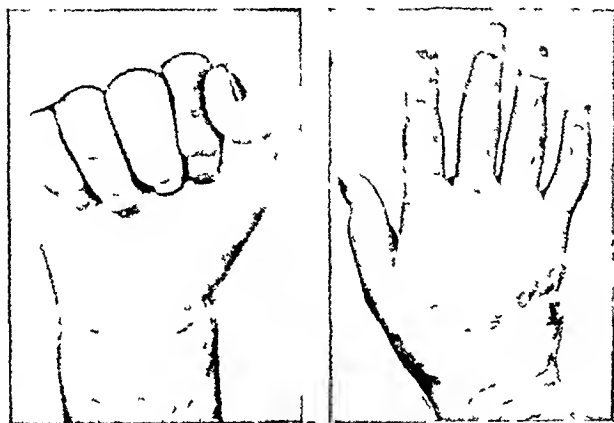


FIG 187—Case J L. Third-degree gasoline burn of the hand incurred in a plane crash May 20, 1944. Split-thickness graft June 2. Same case as shown in Fig 186. Photographed June 28, 1944, showing restoration of function.

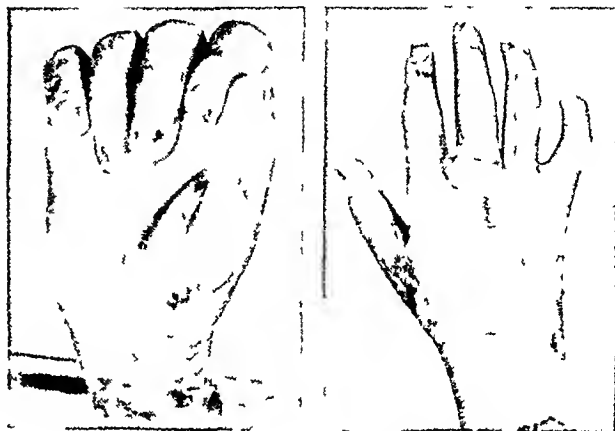


FIG 188—Case A M. Third-degree gasoline burn of the hand in plane crash May 2, 1944. Split-thickness graft June 19, 1944. Photograph of July 5 demonstrates complete viability of the graft except a small area overlying a necrotic extensor tendon of the third finger. Small subepithelial blebs are present on the lateral volar aspect of the thumb. Functional activity approaches normal.

margin and blending of the graft with normal skin occurs during rehabilitation and requires no surgical intervention. Transient cyanosis in the graft during the post-operative period is not uncommon. The appearance of a serous subepithelial bleb is an indication of excessive dependency of the extremity or activity beyond the tolerance of the graft. Elevation should be increased, activity decreased, and bullae aspirated. Occupational exercises and clay modelling are extremely effective. (Figs 187, 188 depict early final results.)

## SUMMARY AND CONCLUSIONS

1 Deformity and disability resulting from thermal burns of the hands may be reduced by early management.

2 Regulations directing the proper use of protective fire-resisting apparel will reduce burned hazards in military operations.

3 Characteristic war-time burns of the hand involve the tissue over the dorsum of the hand and fingers, with a tendency to encircle the wrist.

10 Our success in the treatment of burned hands is attributed to the execution of the numerous suggestions outlined in the text of this paper.

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# AN AID IN THE POST-OPERATIVE MANAGEMENT OF TEMPORARY ILEAL FISTULA AFTER THE LAHEY RIGHT HEMICOLECTOMY

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THE modification of the Paul-Mikulicz plan of operation for lesions necessitating right hemicolectomy, as described by Lahey (1939), claims several advantages: first, it is not a difficult operation to perform; secondly, the operation can be performed in the presence of obstruction, without the necessity for any preliminary operative decompression; and finally, but by no means the least important, by minimizing the danger of peritonitis, a significantly low mortality-rate has resulted from its use. Thus Lahey and Colcock (1942) report a total mortality-rate of 13 per cent by employing the Lahey method of right hemicolectomy for all types of lesion, when the operability rate in the same series was 85 per cent. For the cancer cases in this series, however, they claim a mortality-rate of only 3 per cent. Other observers, using various other techniques, claim mortality-rates varying from just under 12 per cent to over 23 per cent in several series of cases (Rankin, 1932). However, as so few surgeons publish the mortality-rate of a particular method of operation in relation to the operability-rate for that method, comparisons of mortality-rates are therefore not as significant as one might wish. It will be conceded, nevertheless, that a 3 per cent mortality-rate for cancer cases undergoing right hemicolectomy, in the series of cases mentioned above (Lahey and Colcock, 1942), is significantly low, and that the operation can justly claim to be associated with a high degree of safety.

The presence of a terminal ileostomy, even although temporary, is, however, a serious disadvantage of this technique, and is a deterrent to its wider adoption. Thus Gordon-Taylor (1944) remarks that "Paul-Mikulicz procedures on the right side of the belly sometimes may prove a burden scarcely to be borne." On the other hand, Maingot (1942), whilst recognizing the temporary, although trying, burden to the patient of a temporary ileostomy, points out that "this is the price which the patient has to pay for added security."

The object of this paper is to describe a method of managing the ileostomy which in my experience has been found considerably to ease the burden not only of the patient but also of the nursing staff, thereby ensuring to the patient the boon of a safe operation with a minimum of post-operative discomfort.

**Usual Management of the Ileostomy**—The usual history of the post-operative period following a Lahey right hemicolectomy is as follows. For the first 7 to 10 days after the operation the ileostomy drains, either through a tied-in wide rubber catheter or a Paul's glass tube with attached rubber tubing, into a bucket or other receptacle at the side of the bed. Soiling of the skin by ileal contents, with consequent skin irritation and excoriation, and seepage through the dressings, are thus avoided.

At the end of this time, however, the Paul's tube or catheter works loose owing to sloughing of the tied staggered end of ileum. These sloughs are trimmed off and an enterotome is then applied to crush the spur. The ileostomy now discharges into the dressings and on to the skin. The skin, despite protective pastes, becomes excoriated, and the ileal discharge is on occasion so profuse that it not only soaks the dressings but also seeps into the patient's attire and sometimes even into the bedclothes. This seepage, with occasional floodings, of odoriferous, irritating, ileal discharge causes the patient distress, anxiety, and lack of mental and physical rest. To minimize irritation of the skin and provide for the comfort of the patient, frequent copious dressings of wool and gauze are needed. Furthermore, the enterotome requires to be supported by a bulky gauze and wool dressing, which because it not only requires frequent renewal, but also tends to 'ride' up or down on the abdomen, can only act as an uncertain enterotome support. The enterotome generally cuts through the spur in 5 to 8 days, and may have to be re-applied if the spur is considered to be insufficiently crushed by its first application. Whilst the enterotome is in position, the whole of the ileal discharge is on to the skin and into the dressings. When the spur is crushed to a sufficient depth there is a waiting period of 6 to 8 weeks to allow the œdema of the exteriorized bowel to subside before the fistula should be closed. During this waiting period, the mouth of the fistula can be plugged with a wool or gauze spigot so as to shunt the ileal contents into the colon, but even the spigot cannot prevent leakage, with even occasional floodings, of irritating fluid on to the skin.

The stages in the treatment of the ileostomy, outlined above, may be summarized thus—

7-10 days after operation	Paul's tube tied in	No leakage
10-17 days after operation	Enterotome applied	Ileostomy discharges on to skin and into dressings
		Skin around fistula red
3-9 weeks after operation	Ileostomy spigot in use	Some stools, but most of the ileal discharge into dressings
		Skin red and excoriated
10th week after operation	Closure of fistula	

## AUTHOR'S TECHNIQUE

**The Ileostomy Pan**—To overcome the disadvantages arising out of the presence of the ileostomy, the ileostomy pan was devised, tried out, and found highly successful in eliminating the effects of the ileal stream by automatically diverting the irritating fluid away from the fistula without soiling the skin or dressings.

The pan resembles in shape an ordinary bed-pan in miniature. It is made of light aluminium alloy, about  $\frac{1}{4}$  in thick, or of celluloid. The pan has a flat base, circular concave walls, and an outlet tube

The diameter of the base is 5 in, with a central, circular, inlet hole 3 in in diameter. The inlet is large enough to embrace the ileostomy and attached transverse colon fistula, whilst the surrounding flat base provides wide circular apposition to the abdominal wall and at the same time acts as a stage for draining the ileal discharge directly into the outlet tube, or indirectly into the tube via the concave circular walls of the pan. The surrounding circular wall is concave inwards so that when the pan is in position, the obliquity of the anterior abdominal wall causes the concave walls of the lower half of the pan to act as a gutter for conveying discharge into the outlet tube. The outlet tube is fused to the pan so that its floor is on the same plane as the base of the pan, so as to avoid any pooling of liquid. The walls are 2 in high, and the outlet tube 1 in in diameter and  $1\frac{3}{4}$  in long. The pan is open above, or when the enterotome is no longer in use, it can be covered with a lid. To the outlet tube is tied a long piece of inner bicycle tubing (Fig 189) for conveying the fluid into a bucket or



FIG 189—Vaseline gauze pads are in position. The edge of the hole in the centre of the pads is tucked in around the bowel. The tubing is attached to the outlet tube. Ileal contents can be seen spilling out and draining towards the outlet tube.

other receptacle at the side of the patient's bed. This kind of tubing, because of its firmer walls and, therefore, patent lumen, was found to be more suitable than Paul's tubing, the walls of which tend to adhere and so occlude the lumen, resulting in damming up of fluid in the pan.

**The Use of the Pan**—The pan has so far only been used when the fistula has been sited at the upper end of a right paramedian incision (Fig 191). This position for the fistula has been chosen in preference to bringing it out through a lateral stab incision because the more medial site enables the pan to be applied snugly and securely on the comparatively more horizontal surface of the anterior abdominal wall. Nursing the patient in Fowler's position ensures that the fluid gravitates easily into the outlet tube. Furthermore, it is believed that medial siting of the fistula, as opposed to more lateral siting,

minimizes considerably the well-known tendency of the exteriorized bowel to retract within the abdominal cavity. Complete retraction of the fistula into the abdominal cavity through a lateral stab



FIG 190—The pan is maintained in position by firmly strapping overlapping strips of elastoplast. When the enterotome is in use two lateral strips are required in addition to provide lateral support.

incision within the first few days after operation is an accident not unknown.

After the skin incision is sewn up, it is sealed by applying gauze soaked in collodion, which, after drying, is covered with more gauze and then elastoplast, thus securely sealing off the wound. This seal enables the pan to be applied, if need be, to the fistula even before the skin sutures are removed. Sepsis in the laparotomy wound has not been encountered.

The skin around the fistula is thoroughly washed, dried, and then smeared with Ballerina paste or vaseline. Two gauze pads, each about six layers thick and about 7 in square, and thickly impregnated with vaseline or Ballerina paste, are superimposed on each other. A hole is then cut in the centre of the two pads just large enough to allow the exteriorized bowel to be passed through it. When in position, the edge of the gauze hole is tucked up snugly to the bowel wall at its junction with the skin (Fig 189). To render the latter junction watertight, 1-in vaseline gauze is wound around the base of the protruding bowel so that some of this gauze overlaps the gauze pad. The pan is then placed in position so that the fistula protrudes into it through the inlet hole, whilst the outlet tube is so placed that it is at the lowest point of the wall of the pan (Fig 189). The vaseline gauze pads, it should be noted, are not overlapped by the base of the pan. The pan is held in position by the firm application of strips of elastoplast running transversely, each succeeding strip overlapping the first by half its width. Care is taken to see that the upper and lower limits of the pan are well strapped down and sealed off (Fig 190). The firm pressure thus obtained ensures a watertight junction between

the pan and the gauze, and also between the gauze and the skin should any leakage occur under the gauze pads at their junction with the bowel wall. The elastic pressure ensures uniform and continuous pressure of the whole base of the pan against the abdominal wall, despite the respiratory movements and the varying postures the patient adopts during

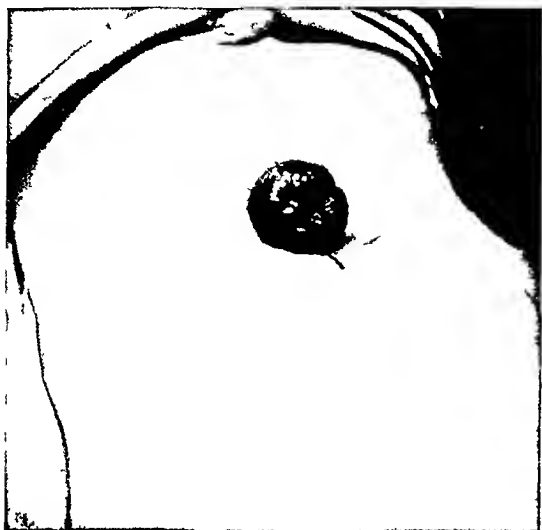


FIG 191—Photograph showing the condition of the skin of the abdominal wall eight weeks after a right Lahey hemicolectomy for Crohn's disease. Vaseline pads and the pan had been in use for six weeks before this photograph was taken.

sleep. The waterproof elastic strapping prevents spillage of liquid even without the use of a lid. When the enterotome is in position excellent support for it is maintained by the additional application of two lateral strips of strapping (Fig 190).

Whilst the pan is in use it is an advantage to feed the patient on a residue-free diet since fruit skins and other cellulose residue tend to stagnate in the pan.

**Advantages of the Pan**—The use of the pan overcomes many of the disadvantages arising from the presence of the ileostomy. The vaseline or Ballerina pads and strapping require readjustment about twice weekly, and if carefully applied, the pan only needs readjustment about every fifth day. There is thus a very considerable saving not only in the number of dressings and quantity of dressing material used, but also of the exertions of the nursing

staff. The patient is thus not disturbed by the almost incessant spillage and leakage of ileal contents on to his skin and into and outside the dressings as occurs when massive gauze and wool dressings alone are used, and he is, moreover, able to move about freely in bed without fear of spillage or of moving the dressings, adequate and undisturbed sleep can thus be promoted. Skin excoriation is obviated or minimal. These advantages are reflected in the cheerfulness and sense of well-being of patients so nursed, in contrast to those patients who had been nursed by using massive gauze and wool dressings. Lastly, the strapping provides all-round steady support for the enterotome when in use.

## SUMMARY AND CONCLUSIONS

1 Right hemicolectomy using the Lahey modification of the Paul-Mikulicz plan of operation is associated with a significantly low mortality-rate, it can be performed in the presence of obstruction without prior decompression, and is not a difficult operation.

2 The chief disadvantage of this operation arises from the effects of the ileal contents discharging on to the skin and into the dressings for several weeks.

3 These disadvantages are overcome by the use of the ileostomy pan, which, by automatically diverting the ileal stream away from the fistula without leakage on to the skin or into dressings, prevents skin excoriation, avoids the necessity for copious and frequent dressings, and thus enables the patient to get adequate mental and physical rest. Furthermore, more reliable fixation of the enterotome is obtained by this method than with gauze and wool dressings alone. Lastly, but not least in importance, the use of the pan drastically spares the exertions of the nursing staff.

I wish to thank the Director-General, Emergency Medical Service, for permission to publish this paper.

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## EXPERIENCES WITH TRANSTHORACIC ŒSOPHAGECTOMY AND GASTRECTOMY

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ŒSOPHAGECTOMY is becoming quite a common operation, and a recent paper by Thompson (1945) (who has the credit of performing the first successful Œsophagectomy with direct anastomosis in this country) sums up the present position. It may be of interest to record experiences with this operation,

which, in spite of the advances which have been made, remains a formidable proceeding. The chief reason for this danger is, of course, the type of patient most commonly encountered, the poor half-starved old man whose general condition makes for inoperability even if his growth does not. That age has



an important bearing on the outcome is not surprising, a study of the ages of any reported cases will show that the recoveries are mostly in the 50's, less often in the 60's, and hardly ever over that. Encouragement may be taken from the fact that the patient of 72 in this series came through his ordeal with less upset than almost any of the others, nevertheless, the vital capacity of a man of over 65 is diminished, and he is liable to stand a prolonged thoracotomy badly. Where the alternative, however, is certain and miserable death, it behoves the surgeon to take his courage and his patient's life in both hands and attack the problem boldly.

The optimum portion of the oesophago-gastric tract for transpleural ablation is the lower third of the oesophagus and the upper third of the stomach. All Trotter's ingenuity and artistry could not produce a high percentage of cures after excision of post-cricoid carcinomas, and it is unlikely that his skill will be excelled. Carcinoma of the mid-oesophagus invades its vital surroundings at an early stage, and even when successfully removed presents serious problems of restoration of continuity. Too often the story of skin-tube repair is one of repeated operations with the patient dying before the last one succeeds, and it is probably better to wait a year after extirpation of the growth to see if recurrence is going to take place before embarking on such measures. A reasonably young subject will stand the multiple procedures involved in bringing the stomach (Kirschner, 1920, Taylor, 1945), or intestine (Yudin, 1944) up to the oesophageal stump antethoracically, but the usual elderly patient will not. Removal and reconstitution of the juxta-cardiac oesophagus and stomach, however, presents no serious technical difficulties even to the general surgeon, and the indications for surgery in this region are now well established with the prospect of completion of a satisfactory one-stage operation.

Total gastrectomy by the abdominal route is always liable to cause anxiety as to the soundness and lack of tension of the anastomosis even if the lower end of the oesophagus is well mobilized. Transthoracic total gastrectomy, of which the biggest series of cases so far has been reported by Churchill and Sweet (1942, a), gives rise to no such fears. In fact, an operation for carcinoma of the fundus involving the oesophagus which is mechanically impossible from below, becomes a simple matter when approached from above. However, a large growth of the fundus may, by its size alone, increase the technical difficulties to such an extent that the consequent prolongation of the operation is more than can be withstood, and such a growth, although mobile, should be considered inoperable in an elderly patient. An old man will stand an open thoracotomy lasting 1½ hours, but is unlikely to survive a 2½ to 3-hour period.

Non-malignant conditions will rarely require to be approached other than abdominally, but it was decided in Case 8 to approach from the thorax on account of the likelihood of massive adhesions and the desirability of this course was borne out by the findings. The ease with which the spleen is removed in the course of operating on the fundus suggests the possibility of the thoracic route being employed

when dense adhesions to the diaphragm seriously hinder an abdominal splenectomy.

## CASE REPORTS

The following cases illustrate certain practical points which will be dealt with subsequently. Cases which have been explored and found inoperable have not been included.

### a Failures—

**Case 1** (June 30, 1941)—G B, male aged 68, 2 weeks' history. Mid-oesophageal carcinoma. Gastrostomy followed by left-sided resection with exteriorization of upper end of oesophagus. Died 2 days later, oedema of lungs.

**Case 2** (July 6, 1943)—H D, male aged 72, 3 weeks' history. Carcinoma, lower third of oesophagus. Left-sided resection and anastomosis.

Died 24 hours later, collapse of lung.

**Case 3** (Oct 22, 1944)—S S, male aged 63, 6 months' history. Large adenocarcinoma of fundus involving cardia, spleen, tail of pancreas. Left-sided resection, lower third of oesophagus, total gastrectomy, splenectomy, hemipancreatectomy, oesophago-jejuno-stomy.

This patient stood the operation remarkably well, but regurgitated milk into the trachea and died of bronchopneumonia 2 days after operation. Fat found in pulmonary alveoli.

**Case 4** (Oct 30, 1944)—G C, male aged 71, 6 weeks' history. Mid-oesophageal carcinoma. Right-sided resection, Kirschner-Taylor extrathoracic anastomosis.

Died 3 days later of acute dilatation of the stomach, unrelied by aspiration. This patient was too old to stand more than resection with exteriorization. The anastomosis should have been left to a second stage.

### b Recoveries from Operation—

**Case 5**—G F, female aged 51, 2 months' history, able to swallow fluids only. Carcinoma of lower end of oesophagus.

Feb 1, 1943. Gastrostomy.

Feb 16. Left-sided resection, cardia closed, anastomosis to fundus. Spleen removed. Water-sealed drain to pleura.

Gastrostomy tube out and swallowing normally in 14 days, full meals in 3 weeks. Convalescence impeded by localized empyema, drained 1 month after operation.

**Pathological Report.** An ulcer 1 in × 2 in in the lower end of the oesophagus involving the cardia. One gland from the lesser curvature contains growth. Microscopical section—squamous epithelioma.

This patient survived 7 months and died presumably of a recurrence. No post-mortem obtainable.

**Case 6**—W W, male aged 72, 6 weeks' history, still able to swallow minced solids. Carcinoma lower end of oesophagus.

Feb 21, 1944. Left-sided resection, cardia closed, anastomosis to fundus. Spleen not removed. No pleural drainage. This was a long growth extending nearly as far as the arch of the aorta, and anastomosis was correspondingly difficult.

Swallowed water at 48 hours, Meulengracht diet in 10 days, full meals at 3 weeks. This patient was hardly upset at all by the operation. At 6 months he had some return of dysphagia which yielded to dilatation with a mercury bougie. When seen at 1 year was swallowing normally and feeling quite well. Had not used his bougie for 6 months. Still alive and well (1 year and 8 months).

**Pathological Report.** An ulcer 3 in × 2 in in the lower end of the oesophagus. Cardia not involved. Microscopical section—squamous epithelioma (Fig 192).



**Case 7**—K P, female aged 48, 5 months' history, still able to swallow minced solids. Carcinoma, lower end of œsophagus.

This patient was a very heavy smoker with a persistent cough and bronchitis, and operation had to be postponed for three months until her chest condition cleared up.



FIG 192.—Photograph showing ulcer in lower end of resected cardia

Oct 30, 1944. Left-sided resection and anastomosis. The growth had extended for 2 in. into the stomach, necessitating resection of the upper third of that viscus, together with the spleen. The œsophagus was anastomosed to the cut end of the stomach. No pleural drainage. Meulengracht diet in 10 days, swallowing full meals at 3 weeks.

This patient developed a stinking localized empyema which cleared up with rib resection. The infection was a mixed one, with some of the organisms penicillin-sensitive, but systemic and local exhibition of penicillin in full doses did not appear to affect the course of the empyema. When seen at 6 months was quite well and swallowing normally. Still alive and well (1 year).

**Pathological Report.** An ulcer involving the lower  $\frac{1}{2}$  in. of the œsophagus and 2 in. of the fundus of the stomach. Microscopical section—squamous epithelioma.

**Case 8**—P H, male aged 46.

**History.** 1928, perforated gastric ulcer, 1932, perforated duodenal ulcer, 1938, gastrocolic fistula.

The operative treatment of these conditions had been carried out elsewhere, and he arrived with another gastrocolic fistula, for which I performed a subtotal gastrectomy on Nov 22, 1943. He reappeared 10 months later with a jejunal ulcer, and it was obvious that nothing short of a total gastrectomy would discourage the ulcerous enthusiasm of his stomach.

Sept 24, 1944. In view of the massive adhesions in his abdomen it was decided to remove what remained of his stomach transpleurally. It was remarkable how easy by this approach was the undoing of the anastomosis, reconstitution of the jejunum, resection of the stomach, and œsophago-jejunostomy. The spleen was not removed nor was the pleura drained, and the patient was less upset by the operation than a man in the next bed who had a straightforward partial gastrectomy for ulcer on the same day.

He has had no trouble with swallowing or fullness after meals, and his blood-count is being checked at regular intervals. Alive and well 1 year after operation.

## DISCUSSION

**1 Preliminaries.**—The diagnosis must be established with certainty by X-ray examination, œsophagoscopy, and biopsy. If the patient has been starved by his obstruction it is necessary to

make him as fit as possible for his ordeal. If he is fortunate it will occasionally be found that he can still swallow fairly well, in which case it is only necessary to put him on a high protein diet and correct any anaemia by blood transfusion. Gastrostomy or jejunostomy may be required, but as gastrostomy may interfere with the subsequent manœuvres by tethering the stomach it is preferable if possible to dilate the stricture with Plummer's bougies. If gastrostomy is performed it is an advantage to pull the stomach as far over to the left as possible and insert the catheter near the pylorus, leaving the fundus and body free. Pre-operative induction of pneumothorax is unnecessary. A blood-drip during operation is essential.

**2 Approach.**—The lower œsophagus and fundus of the stomach are more easily accessible from the left side, the mid-œsophagus from the right. Indeed, the whole of the œsophagus is more easily exposed from the right, the easily-disposable vena azygos being the only intervening structure, but on this side the approach to the abdomen is hindered by the liver. It is possible, however, after opening the right side of the diaphragm, to divide the falciform and coronary ligaments of the liver and rotate the liver temporarily up into the chest, thus facilitating the intra-abdominal manipulations.

Owing to the extreme obliquity of the thoracic inlet, growths in or extending into the upper part of the thoracic œsophagus are much nearer the cricoid than would appear on thoracotomy, with the result that after adequate resection the remaining stump of œsophagus would be too short to permit of reasonably easy anastomosis, or even exteriorization. Such tumours should at present be regarded as inoperable.

**3 Choice of Anæsthetic.**—Cyclopropane is used extensively in thoracic surgery, but in the capable hands of my anæsthetic colleague avertin, followed by gas and oxygen, with the addition of a little chloroform from time to time to damp down any tendency to excessive respiratory movements, has given a beautifully smooth anæsthesia.

**4 Incision.**—A long intercostal incision has been used in all these cases, extending from the costal cartilage in front to the transverse process behind, cutting across the erector spinæ. Division of the neck of the rib above and below allows of wider retraction, injection of proctocaine or removal of a segment of rib to avoid after-pain has proved unnecessary. The space used depends on the situation of the growth, the 7th permits easier access to the region of the arch of the aorta, the 9th to the far side of the abdomen. If more room is required in an upward direction the necks of one or two ribs, together with the intercostal structures, can be divided, and hæmorrhage can be controlled by passing a ligature around rib and vessels.

**5 Approach to the Mediastinum.**—The lung will frequently be found adhering to the parietal pleura, particularly in the paravertebral gutter. Division of the adhesions and the ligamentum latum pulmonis up as far as the inferior pulmonary vein gives adequate exposure. The œsophagus is less intimately connected with the left pleura than it is with the right, incision of the former is usually all that is required to explore the growth and the

mediastinum, whereas a segment of pleura together with vena azygos may have to be removed on the right side

Care must be taken while freeing the growth to avoid tearing the opposite pleura, although with positive pressure anaesthesia this accident is of little moment as the lung can be kept working till the rent is repaired. In mid-oesophageal growths the left pleura is kept out of harm's way by the aorta, but the lower medial angle of the right pleura comes surprisingly far over to the left and is easily torn unless this point is remembered (Grey Turner, 1936)

**6 Approach to the Abdomen**—After crushing the phrenic nerve the diaphragm is incised radially from the oesophageal hiatus. The hiatus itself may be involved in the growth and a segment excised. The division of the medial part of the

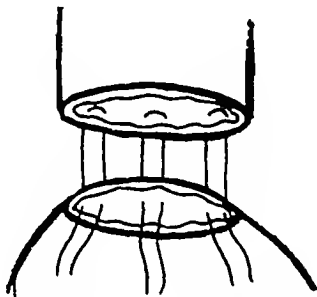


FIG 193—Interrupted through-and-through sutures in outer layer of anastomosis

diaphragm is facilitated by using a finger passed through the hiatus from below as a retractor. The abdomen is explored, particularly the fundus of the stomach, the liver, and the coeliac and lesser curvature glands. If at this stage the condition is found to be inoperable the diaphragm and chest can be closed with as little after-effects as from an exploratory laparotomy, and probably less, certainly there is no risk of a burst abdomen!

**7 Removal of the Growth**—The oesophagus is mobilized above the growth and a gauze retractor passed round it. The growth itself is then freed, but if this proves at all difficult it may be easier to mobilize the stomach first and then the growth. Dissection in the region of the arch of the aorta does not appear to cause undue upset when carried out from the right side, but any tunnelling behind the aorta in the course of a left-sided exposure is liable to provoke hostile comments from the anaesthetist watching the pulse and blood-pressure. It is immaterial whether the spleen is removed with the stomach or not, the decision rests entirely on which course is easier. The greater curvature of the stomach is freed and the lesser omentum divided, the greater omentum is removed if the stomach is widely involved. The coronary vessels are ligatured as near the coeliac axis as possible, and the glands along the lesser curvature are stripped upwards towards the cardia. That this is a most important step in the operation is shown by the figures of Churchill and Sweet (1942, b), demonstrating that 50 per cent of growths of the lower oesophagus, and even 30 per cent of mid-oesophageal growths, metastasize below the diaphragm.

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The oesophagus and stomach are then cut across well above and below the growth. The stomach can quite easily be cleared as far as the pylorus, in fact, the peritoneum on the right side of the duodenum can be divided so as to mobilize it still further, and the extent to which intra-abdominal manipulations are possible is shown by Case 8. The right gastro-epiploic artery carries ample blood to nourish any stomach which may be left, but no fears need be entertained for the viability of this very vascular viscus. Hey's ligature operation for duodenal ulcer involves tying every possible artery supplying the stomach which then depends solely on vessels reaching it via the walls of the duodenum and oesophagus, yet I have never seen any harm come to the stomach following its performance.

**8 The Anastomosis**—A direct primary anastomosis is the most desirable course, and in growths

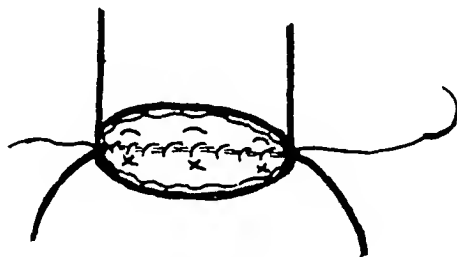


FIG 194—Continuous through-and-through inner suture

of the lower oesophagus and stomach this is generally feasible. The fundus of the stomach can be pulled much farther up into the chest than the cardia, so the simplest plan is to close the cardia and anastomose the cut end of the oesophagus to a fresh opening in the fundus, as suggested by Ogilvie (1938). There are many ways of doing this, but in my hands Grey Turner's interrupted through-and-through mattress sutures anteriorly and posteriorly (Fig 193) have provided a firm outer layer supporting a continuous through-and-through inner suture (Fig 194). If the anterior part of this continuous suture inverts rather than everts the apposed surfaces, it will be found that the fourth layer will bury it neatly with greater ease.

With regard to the oesophagus as material for suturing, the following experiment was carried out in order to determine its tensile strength relative to that of the stomach. An oesophagus was removed from a body within 6 hours of death and a stitch passed through all its coats approximately  $\frac{1}{4}$  in from the cut end. Lead shot was poured into a tin suspended from the stitch until it cut out, when the tin with its contents was weighed. The mean of six such attempts was taken and the average weight found to be  $2\frac{1}{4}$  lb with a variation of  $\frac{1}{4}$  lb either way. A similar series of stitches was taken through all coats of the stomach from the same subject, when the mean cutting-out weight proved to be  $4\frac{1}{4}$  lb. The bite of the stitches was measured by eye so as to conform to conditions in actual practice. This shows that, provided a good bite is taken of all coats, the oesophagus will stand nearly half as much tension as the strong stomach, which is surprising.

in view of the friability of the œsophageal muscle and the absence of a peritoneal coat

If the stomach is cut across below the growth it may still be possible to perform an œsophago-gastrostomy, but the technical difficulties of apposing a short to a long stoma are greater. If much stomach has to be removed it will be found easier to close the lower end and bring the jejunum up instead. The jejunal mesentery may be long enough to allow it to come up without tension, but if it is short it will have to be mobilized in the manner described by Yudin (1944). The main vessels supplying the jejunal arcades are completely cleared of peritoneum and tied as near the superior mesenteric as possible, the arteries are tied separately from the veins. If these precautions are not taken the ligatures tend to slip off when the gut is put on the stretch. The vigorous peristalsis which follows division of the vessels is most striking and is a great nuisance in that it forces the mucosa out of the jejunal stoma, interfering with the performance of the anastomosis. An end-to-side œsophago-jejunostomy similar to that described for the fundus of the stomach is perfectly satisfactory, but the method of Roscoe Graham (1940) may be used. In this the jejunum is attached to the back of the œsophagus above the cut end (Fig 195), and after the anastomosis has been made the proximal jejunal loop is wrapped and stitched over the front of the anastomosis so as to include it between two peritoneal surfaces (Fig 196).

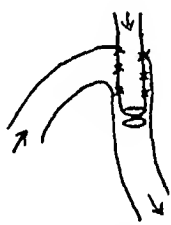


Fig 195

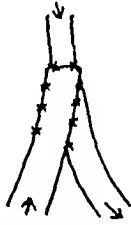


Fig 196

Figs 195, 196—Roscoe Graham's method of œsophago-jejunostomy (see text)

An entero-anastomosis between the jejunal loops may be performed, but is unnecessary with a straightforward anastomosis.

**9 Closure**—The diaphragm is closed around the viscus herniated into the chest and the rest of the closure completed in the usual way.

**10 Drainage**—It does not seem to matter much whether the pleura is drained or not. It would seem advantageous not to leave a collection of blood as a nidus for infection, but of the cases which recovered the one which was drained developed an empyema whereas only one of the three which were not drained did so.

**11 Duration of Operation**—The shortest time for the complete operation in this series has been 1 hour 40 minutes, the longest 3 hours. If the patient is over 60 he will begin to flag after 2 hours.

**12 After-treatment**—Continuous gastric or intestinal suction combined with rectal or intravenous

drip (taking care with the latter not to waterlog the lungs) combats distension and dehydration and yet allows the uplift to morale of occasional sips of water. Feeding by mouth can be commenced quite early and can be gradually increased. The B.L.B. mask has been used to combat anoxæmia, but although good in principle its practical value has been doubtful.

### 13 Complications—

**a Shock**—Many patients will die in the first 24–48 hours, and nothing will save them.

**b Collapse of the Lung**—The lung collapsed at operation will expand as the water-sealed drain comes into play, or it can be blown out before closure of the chest and will usually stay expanded. More serious is collapse due to blockage of the bronchus, which may necessitate early passage of the bronchoscope, mucus may be found and sucked out, but possibly the forcible coughing which usually accompanies introduction of the instrument does just as much good. Collapse of the opposite lung is an even more disappointing complication.

**c Œdema of the Lungs**—Too much intravenous saline may be responsible, but even when this has not been administered œdema is liable to develop at both bases and nothing will check it.

**d Empyema**—Infection of the pleura might be expected in every case, but even with the most septic growths it does not necessarily supervene. Small effusions will probably be absorbed, while if larger they may be aspirated or drained.

**e Leakage of the Anastomosis**—This has not been encountered in the present series. Either leakage has not occurred or the patient has died before it could take place.

**f Stenosis of the Anastomosis**—One of the four survivors developed dysphagia, which was relieved by the passage of a mercury bougie.

From the foregoing it may be concluded that if a patient is not too feeble and does not harbour too advanced a growth, if he survives the operative onslaught, if he does not die of collapse or œdema of the lungs in the first 48 hours, and if he negotiates successfully the hazards of an empyema, he will at least swallow in comfort for the rest of his life and stand a sporting chance of prolonging his existence.

I am indebted to Mr W. H. Ogilvie for his literary criticism of this report, and no worker in this field can omit a record of his indebtedness to the pioneer work of Grey Turner.

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## PENICILLIN TREATMENT OF ACUTE HÆMATOGENOUS OSTEOMYELITIS

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ACUTE osteomyelitis provides an excellent ground for testing the efficacy of new bacteriostatic or bactericidal drugs. Their value in this disease must be assessed by measuring the extent to which they fulfil the two principal aims of treatment—first, the saving of life by overcoming the initial septicæmia or pyæmia, and secondly, the cutting short of local infection and the limiting of bone necrosis. In this paper, penicillin treatment of 40 patients will be discussed from both standpoints, except that assessment of the state of the local bone lesion is limited to 32 cases in which long bones were affected.

### METHODS OF TREATMENT AND CLINICAL COURSE

**Administration of Penicillin**—All patients have been treated in the wards of the Royal Infirmary and the Royal Hospital for Sick Children, Edinburgh. A daily dose of 100,000 units of penicillin has been used, although some patients with septicæmia received a daily dose of 200,000 units until there was evidence that the septicæmia had been controlled. The daily dose was given in 100 c.c. of sterile normal saline and the 'Eudrip 3' apparatus for continuous infusion was found to be the most convenient method of administration. The solution was given either intramuscularly (29 cases) or through an intramedullary needle\* (11 cases), the small volume of the daily dose made the latter route possible even in very young children, over a period of 21 days. Both methods have been found effective, the intramuscular route is more easily supervised by the nursing staff, although the site of infusion must be changed every second day, whereas by the intramedullary route it has been possible to maintain infusion for 21 days without changing the position of the needle. The aim of intramedullary administration is to provide a high concentration of penicillin locally and at the same time to secure sufficient absorption into the bloodstream to control general infection.

Approximate estimation of the level of penicillin in serum (or pus) was made by a method which has been used in the Bacteriology Department of Edinburgh University, and which will be described fully elsewhere. This method may be outlined as follows. The serum (or pus filtrate) is serially diluted with nutrient broth and inoculated with a standard loopful of a diluted culture of the Oxford strain of *Staph aureus*. After incubation, the tubes are examined for growth and the highest dilution

in which no growth has occurred is noted. Partial stasis may also be observed and interpretation of the results is facilitated and confirmed by subsequent plating on blood-agar from each dilution.

Some of the results are recorded in the following tables.

As all patients received 100,000 units of penicillin a day, irrespective of their age, it is not surprising to find a wide variation in the serum bacteriostatic level (Table I). Failure to maintain a uniform rate of intramedullary administration in the first few days of treatment resulted in 3 serum specimens showing no bacteriostasis (Table I).

From the above tables it will be seen that intramuscular infusion produces almost the same range of serum bacteriostatic levels as intramedullary, but a lower concentration of penicillin in the pus.

For the effective treatment of an infection with penicillin, it is still uncertain what bacteriostatic level should be maintained in the patient's serum; it would appear to depend on many factors, but

Table I—SERUM BACTERIOSTATIC LEVELS OBTAINED DURING THE ADMINISTRATION OF 100,000 UNITS OF PENICILLIN PER DAY

	NUMBER OF SERUM SPECIMENS	
	Intramedullary Administration	Intramuscular Administration
No stasis in undiluted serum	3	—
Partial stasis in undiluted serum	3	2
Complete stasis in undiluted serum	9	8
" " " serum diluted 1-2	14	12
" " " " " 1-4	2	5
" " " " " 1-8	2	4
Total	33	31

Table II—BACTERIOSTASIS IN INTRAMEDULLARY PUS DURING ADMINISTRATION OF 100,000 UNITS OF PENICILLIN PER DAY

	NUMBER OF SPECIMENS OF PUS	
	Intramuscular	Intramedullary*
Partial stasis in undiluted pus	1	—
Complete stasis in undiluted pus	4	—
" " " pus diluted 1-2	4	—
" " " " " 1-1000 or higher	—	8
Total	9	8

\* Pus specimens taken from intramedullary needle at site of infusion

not least on whether the infection was general (septicæmia) or local (abscess). The serum bacteriostatic level required in treating a septicæmia presumably varies with the penicillin sensitivity of the infecting organism, while the determining factor in a localized infection is the permeability of the wall of the cavity to the passage of penicillin.

At first it was thought that for a general infection penicillin administration should aim at producing

\* Intramedullary infusion is carried out through a sternal puncture needle inserted into the metaphysis of the infected bone.

complete bacteriostasis in serum when diluted 1-2, but in this series recovery from staphylococcal septicaemia has been possible when the patient's serum showed complete stasis in undiluted serum only. *Table II* shows that after intramuscular administration (100,000 units per day) penicillin passes freely into the pus of the local bone lesion.

The intramedullary method appears particularly suitable where the infected metaphysis is intracapsular (neck of femur) and there is an almost inevitable septic arthritis. In view of the successful results obtained by this method, it would appear that in such cases a route is open for the passage of penicillin from metaphyseal focus to infected joint cavity.

The introduction of a needle into the medulla of an infected bone can also be used for purposes other than administration of penicillin. First, during its insertion it allows of aspiration of a subperiosteal abscess, and when introduced further, through the cortex, it relieves intramedullary tension (*Fig 197*). Secondly, by aspiration of pus a precise

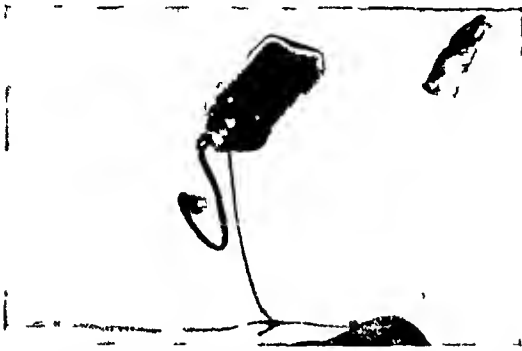


FIG 197—Intramedullary decompression drainage through an intramedullary needle. In this case 90 cc of infected fluid were drained in the first three days.

bacteriological diagnosis can be made, and later the time of clearance of organisms from the marrow accurately determined. These clearance times (sterilization times) are of the utmost importance in deciding the duration of treatment. *Table III* shows that in 18 patients the average clearance time for staphylococcal infections was 14 days. In most patients treatment was continued until three successive daily specimens of pus proved to be sterile. Temperature chart and leucocyte-count were found unreliable as guides to the severity of local infection. Our observations of clearance times support the practice in staphylococcal infections of continuing treatment for not less than 14 days; the single proved haemolytic streptococcal infection responded more rapidly.

#### General Response to Penicillin Treatment

—There are two well-defined clinical types of osteomyelitis, and the response to penicillin treatment supports this classification. The first group includes patients with evidence of septicaemia in addition to a local lesion of bone; the second group comprises those with a local lesion only. Of our 40 patients, 21 had a generalized infection, 10 had metastatic foci and 20 had positive blood-cultures. The clinical response in these patients was not dramatic

They remained critically ill for 3-7 days, and often there was little encouragement to be gained from the temperature chart. Improvement in general well-being was usually the first reliable indication that treatment was proving effective. The blood-cultures

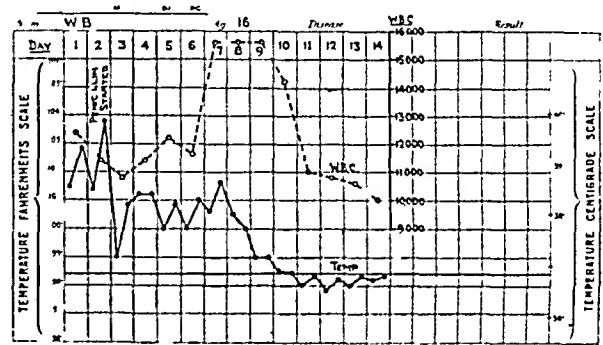


FIG 198—Case 25. Temperature chart and leucocyte response of patient with a septicaemia (first clinical type).

became sterile, on an average in 3 days, whereas the temperature remained raised for 7-14 days, finally settling by lysis. The leucocyte-count usually paralleled the fall in temperature, but occasionally, when low at the start of treatment, it was observed to rise while the general infection was being controlled. This should not be interpreted as indicating a further spread of infection, but rather as a favourable prognostic sign (*Fig 198*).

*Table III* shows that 10 of the 21 patients in this group had metastatic lesions on admission to hospital. There were 6 staphylococcal pneumonias, 2 soft-tissue abscesses, 2 metastases to other bones, and 1 septic pericarditis. The soft-tissue abscesses were drained and healed rapidly; the pneumonias were controlled within 7 days; and the patient with a septic pericarditis was treated by aspiration and local instillation of penicillin, which sterilized the pericardial effusion in 9 days.

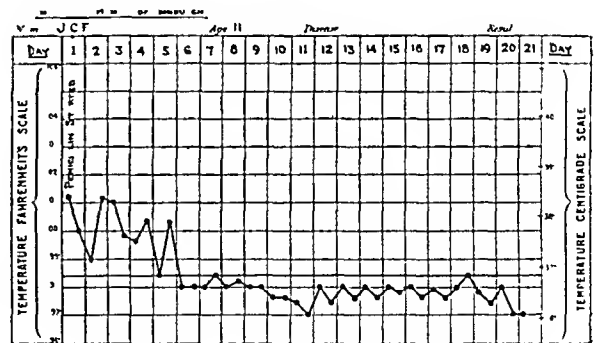


FIG 199—Case 21. Temperature chart of patient with local bone lesion only (second clinical type).

The second clinical type includes 19 patients with a varying degree of toxæmia in whom the general condition was good, the blood-cultures were negative, and there were no metastatic lesions. The temperature usually subsided within 7 days of the start of treatment, and general improvement was obvious before this time (*Fig 199*).

# PENICILLIN IN HÆMATOGENOUS OSTEOMYELITIS

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## 'Local' Response to Penicillin Treatment

—It has been shown that penicillin controls general infection, and it is now necessary to consider what form of local intervention, if any, is desirable. The operative procedures which can be utilized include bone guttering, bone drilling, and incision or aspiration of subperiosteal abscesses.

centres, and the findings suggest that although there is a low mortality-rate, no dramatic improvement resulted in the local lesion in bone, where pus continued to form and sterilization was too slow to prevent the formation of sequestra. In the great majority of our patients a conservative regime was followed in order that the effects

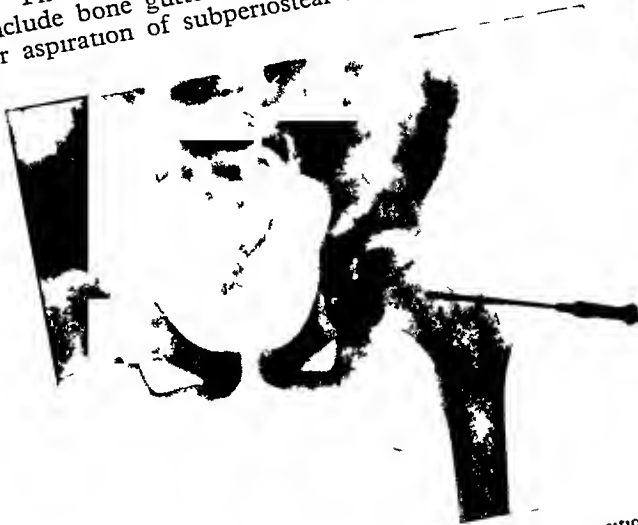


FIG 200—Case 2 Intramedullary needle in position. Minor bone changes present. Septic arthritis proved by joint puncture.



FIG 201—Same case, showing immobilization in a Thomas splint and increasing decalcification two weeks after penicillin treatment.

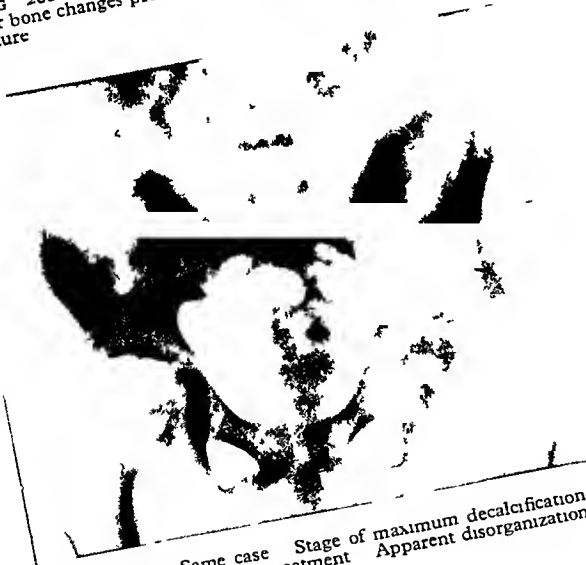


FIG 202—Same case. Stage of maximum decalcification six weeks after penicillin treatment. Apparent disorganization of bony architecture.



FIG 203—Same case. Stage of decalcification fifteen weeks after penicillin treatment. Reappearance of trabeculation and preservation of joint space.

- 1 Bone guttering is favoured by those who have as their guiding principle effective drainage, which, in their view, is procurable only by extensive removal of the cortex overlying the infected metaphysis. Certainly drainage is free, but inevitably healthy bone is exposed and there is danger to life from the displacement of septic thrombi.
- 2 Incision of subperiosteal abscess and bone drilling are attempts to combine effective drainage of the bone with a minimum of surgical interference.
- 3 Aspiration of subperiosteal abscess and immobilization in combination with the administration of sulpha drugs has been investigated in various

of penicillin treatment could be observed uncomplicated by other factors. Table III shows that in our series 32 patients with acute infections of long bones were treated with penicillin. Of these only 5 had operative treatment, the remaining 27 being treated conservatively. Of the 5 patients operated on 4 were amongst the first to be treated before the effectiveness of penicillin was fully appreciated, and were not selected according to the severity of the lesion. The remaining patient was a neglected case of 13 days' duration, a small incision was necessary to anticipate the development of a spontaneous sinus,

the skin being unhealthy and pus having already ruptured through the periosteum

Aspiration of a subperiosteal abscess alone was carried out in 2 of the 27 patients treated conservatively, and in 15 a sternal puncture needle was inserted into the affected metaphysis for relief of intramedullary tension. Since there was no obvious abscess in the remaining 10 patients, 8 were treated by simple immobilization of the infected limb, and 2 were treated without immobilization. After aspiration, the subperiosteal abscess did not in any case progress to sinus formation. In *Case 21* (*Table III*), 6 c.c. of thick pus were aspirated from the subperiosteal space on the fourth day of treatment, but further attempts to aspirate on the sixth

more attention than those treated without radical operation, and in addition their periods of hospitalization and incapacity were longer

In 10 of the 40 patients septic arthritis occurred. This complication is probably most effectively treated by aspiration of pus and local injection of penicillin into the joint cavity every second day. Repeated aspiration of a relatively inaccessible joint (hip-joint), however, is not always practicable and systemic treatment has to be relied upon. It is thought that penicillin in detectable amounts will not pass from the blood-stream through a healthy synovial membrane, but there is evidence that it will do so when the joint is infected, provided the dose is suitably adjusted. All our patients received

systemic penicillin treatment.

In 5 local treatment was not possible on account of infection of a hip-joint, in 4 patients, as the limb was incorporated from the first day in plaster-of-Paris, a septic arthritis was not diagnosed, thus 1 patient only received additional local treatment. As a result of this treatment, 3 patients have complete destruction of the joint with bony ankylosis, 4 have a varying degree of limitation of movement, and 3 have complete return of function with no radiological evidence of previous infection (*Fig 203*).

Except in patients with septic arthritis, the period of immobilization was reduced to a minimum in order that early active movements could be encouraged. Weight-bearing, however, was postponed until there was radiological evidence of recalcification.

#### Functional Results —

The causes of prolonged incapacity and poor functional

results are massive sequestra formation, discharging sinuses, septic arthritis, and pathological fractures. It is possible to assess the effects of treatment in 22 of the 32 patients who had infection of long bones. In 2 poor function has resulted because of destruction of a joint, 1 has a pathological fracture, and 2 have discharging sinuses. In the remaining 17 patients good function has resulted.

**Radiological Appearances** — An assessment of the sequence of the radiological changes which accompany the process of healing has been possible in 22 patients with infection of long bones. As already pointed out, penicillin treatment sterilizes bone on an average within 14 days (*see p 168*). Before sterilization, damage to bone has occurred, but for some time the extent of damage does not become evident radiologically. Early radiological changes are evidence of the degree of initial bone damage, later changes are part of a process of healing, and cannot be attributed to continuing infection.

The outstanding radiological features in early infection are the extensive decalcification, the limited



FIG 204 — Same case. Showing function fifteen weeks after penicillin treatment

day were unsuccessful, indicating that the metaphyseal infection had been brought under control. In *Case 19* (*Table III*), a large fluctuant subperiosteal abscess extended two-thirds up the shaft of the tibia, and it was possible to aspirate 8 c.c. of thick pus. Sequestrectomy has been unnecessary and exacerbations have not occurred in any of the patients treated by aspiration and immobilization.

The results of more extensive operative treatment in 5 patients have not been so encouraging. An excellent result was obtained in *Case 30* (*Table III*), but in the other 2 cases (*Cases 29 and 31, Table III*), where it has been possible to assess the effectiveness of treatment, both developed sequestra which required removal, and still have discharging sinuses after 11 and 7 months respectively. The sequestra were superficial in type, and in each case corresponded to the point at which the periosteum had been raised at operation. The wounds became secondarily infected with Gram-negative organisms which caused a persistence of suppuration after the *Staph aureus* had been eliminated. These patients required



amount of subperiosteal bone formation, and the absorption of small sequestra. Decalcification in most cases has been widespread, on occasion involving the whole of the infected bone. Patchy and ill-defined areas of rarefaction occur first in the metaphysal area and later spread to the adjacent shaft. For 70–140 days the decalcification is progressive, and owing to the small amount of periosteal new bone formation, the process can be readily observed. These changes presumably occur in cases not treated by penicillin, but they are masked by a denser involucrum. The trabeculations become ill defined and irregular to an extent which would suggest permanent structural disorganization of the bone (*Fig 202*). In view of these changes, immobilization would appear advisable until there is radiological evidence of recalcification (*Fig 205*).



FIG 205—Case 26 Pathological fracture—limb not immobilized

illustrates the danger of treatment without immobilization—a pathological fracture occurred through the epiphysis and adjacent shaft.

Small sequestra have developed in 5 of the patients treated conservatively, and the fate of these is being followed by repeated radiological examinations. In 2 cases complete absorption has been observed, and in the remaining 3 cases there is at present no indication that sequestrectomy will be necessary. The behaviour of these small sequestra appears to be similar to that of bone chips introduced to facilitate ossification—both are sterile and both require absorption before final healing can take place.

With one possible exception in a recent case still under treatment, excessive periosteal new bone formation has not occurred, nor has there been wide separation of the periosteum from the cortex, presumably because the bone destruction has not been so great as in cases treated without penicillin, and there is no necessity for massive involucrum formation to maintain support. Further, as pus formation is rapidly controlled by penicillin, the degree of periosteal elevation is limited.

**Progress in Healing**—Recalcification is somewhat irregular but remarkably resembles the original pattern, more so than might have been anticipated from earlier X-ray examinations. *Fig 203* shows

the reappearance of trabeculations after their apparent destruction (*Fig 202*). The absence of massive sequestra has facilitated early healing, the absorption of smaller sequestra has resulted in localized areas of sclerosis. The interval which previously separated the subperiosteal new bone from the cortex has gradually narrowed, and fusion with the shaft has been interpreted as indicating that the lesion has become inactive. The limited amount of periosteal bone formation has maintained a moderately regular outline of the bone, and has prevented gross deformity (*Figs 206–210*).



FIG 206—Case 21 Stage of 'healed' lesion (twenty-eight weeks)



FIG 207—Case 18 Stage of 'healed' lesion (sixty weeks)

**Prognosis**—Before the discovery of an effective chemotherapeutic drug, Kenny (1944) reported that in a series of 1547 cases there was a mortality of 23 per cent, and in toxic patients where the temperature reached 103° F or where the patient was septicæmic, the mortality rose to 46 per cent. One-third of these patients developed metastases. With the introduction of the sulpha drugs, the mortality-rate has been reduced. Out of 38 consecutive cases treated with sulphathiazole in a ward of the Royal Hospital for Sick Children, there was a mortality of 10 per cent, and of 9 patients with a proved septicæmia 4 died.

In this series of 40 patients treated with penicillin there was only 1 death, despite the fact that 19 of these patients had a staphylococcal septicæmia, 9 had metastatic lesions, and 10 had a septic arthritis. This patient had a partially resistant *Staph aureus* infection (four times more resistant than standard

Oxford *Staph aureus*) and died from broncho-pneumonia 42 days after the start of treatment. None of the septicæmic patients developed new metastatic lesions after the start of treatment.

It appears, therefore, that recovery can be anticipated in every patient with acute hæmatogenous osteomyelitis treated with penicillin, provided that the infecting organism is penicillin-sensitive and that the patient is not *in extremis* when first seen. It is possible that for these reasons the general

involucrum formation, the preservation of bony architecture, and the absence of gross deformity

**Acknowledgments**—Some of these cases have been treated by penicillin supplied for research purposes through the Penicillin Clinical Trials Committee of the Medical Research Council.

I wish to thank Professor J R Learmonth, whose help and advice have made this work possible, Professor T J Mackie, in whose department the



FIG 208—Case 17 Stage of healed lesion (forty weeks)

FIG 209—Case 16 Stage of advanced recalcification (ten weeks) Small sequestrum present

FIG 210—Case 14 Stage of healed lesion (twenty-four weeks)

mortality-rate will remain in the neighbourhood of 5 per cent.

### SUMMARY AND CONCLUSIONS

1 Penicillin treatment of 40 cases of acute hæmatogenous osteomyelitis is described, attention being focused on 32 patients with infection of long bones.

2 The mortality was 2.5 per cent, despite a 50 per cent incidence of *Staph aureus* septicæmia.

3 The best results were obtained when conservative methods were employed. Secondary infection with penicillin-resistant organisms was obviated, no spontaneous sinus developed, and as yet sequestrectomy has not been necessary.

4 Radiologically it would appear that devitalization has been cellular rather than massive, as shown by the absence of large sequestra and of massive

bacteriology was carried out, Mr Ian Aird, who is responsible for the method of intramedullary administration of penicillin and in whose wards in the Royal Hospital for Sick Children, Edinburgh, a number of the patients were treated, Dr J P Duguid for much help with the clinical and bacteriological work, and Dr R McWhirter for his interest and help in the interpretation of the X-ray films. I am also indebted to the surgeons-in-ordinary of the Royal Infirmary, Edinburgh, for permission to treat patients in their wards.

The illustrations have been prepared by the technical staff of the Wilkie Surgical Research Laboratory, University of Edinburgh.

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# HORMONAL BIOASSAY IN MALIGNANT TESTIS

## THE STATUS OF HORMONAL BIOASSAY IN MALIGNANT DISEASE OF THE TESTICLE

### A REVIEW OF THE LITERATURE

BY R S FRANCIS, SURG-LIEUT, R N V R

CONTROVERSY has raged for decades over the subject of growths of the testicle. The giant protagonists of the early days were Ewing and Chevassu. Followers of the former believed most tumours to be derived from totipotent cells, which conveniently accounted for the bewildering heterogeneity and varying malignancy of such growths, whilst supporters of the latter contended that there was in addition a distinct group of neoplasms derived from the spermatogenic tubule cells, to which Chevassu gave the name seminoma. Such tumours have been recognized histologically by common consent, and their integrity has been respected by most authors. As to the status of the heterogeneous group, the nomenclature has become confounded beyond all reason. 'Teratoma' has come to connote any malignant or benign neoplasm of the testicle with the possible exception of the seminoma. Other names are applied, depending on the type of tissue which predominates. Thus, chorionepitheliomata, embryonal adenocarcinomata, and carcinomata, "teratoid with cancerous elements", mixed adult types with cancerous areas, malignant types with adult tissue, and all the possible permutations of tridermic growths of varying malignancy which, on account of their mixed structure, do not justify separate classification.

A further fillip was given to this controversy when Zondek published in 1930 his discovery that malignant tumours of the testis caused the urine of their owners to give a positive Aschheim-Zondek pregnancy test. The subsequent fourteen years, therefore, saw a series of attempts to correlate hormone production with prognosis, and a tendency to re-classify these growths on a hormonohistologic basis. Notable amongst these investigators were Ferguson (1933), Herger and Thibandear (1934), Cutler and Owen (1935, 1936, and 1937), Hinman et al (1942), Rosenblatt et al (1942), Ferris (1943), and Powell (1938), Hamburger (1936), Twombly et al (1942), Fortner and Owen (1935), and other writers who reported one or two cases (Beilly et al, 1940), but did not publish their figures. All these writers used material ranging from untreated urine to acid-alcohol precipitated extracts, or urine treated by the benzoic acid flocc technique. Again, the interpretation of the quantitative tests tended to differ, and there has been variation in the test animal used (rat, rabbit, mouse). Conclusions have ranged from encouraging to disappointing, confounding to convincing—in fact, they have been anything but uniform.

Thus to the clinician confronted with a tumour of the testicle any attempt to consult the literature on the significance of the Aschheim-Zondek reaction is bound to prove somewhat disappointing at the present stage. It was with this in mind that the work embodied in the present paper was undertaken.

Most of the available literature for the last fourteen years, following Zondek's observation, has been reviewed, and special attention has been paid to those authors who have published investigations of large numbers of cases. The field covers over 300 tumours of the testis, mostly malignant, and varying in their histology from the adult type of 'teratoma' through an increasing range of embryonic cell type and malignancy to the chorionepitheliomatous type or growth. For details of cell type, hormone output and reference, see Table I, which is an attempt to incorporate in one unit all the varying terminologies used by different investigators, with their hormonal figures. Table II is an abstract of the figures, and here certain sub-groups of tumours are unified under a few main headings. Table III represents a simplified classification of all the cases collected, with the exception of those in Table IV, which consists of results of Hamburger's series.

### DISCUSSION ON THE TEST

Zondek in 1930 examined the urine of patients suffering from malignant disease of the testis. He found that, as with pregnant women's urine, the following results were obtained in the test animal's ovary—

- 1 Ripening of the Graafian follicle
- 2 Hæmorrhage into the cyst
- 3 Gross enlargement of the uterine horns

Ferguson in 1933 stressed the importance of reaction (1) in male urine, and interpreted the occurrence of reactions (1) and (2) in 1 ml of urine as indicating the presence of 1000 mouse units per litre. If luteinization and the formation of corpora atretica occurred (reaction 3), then Ferguson simply inferred that there was five times as much hormone (i.e., 5000 m u / l) present in the urine than was indicated by reaction (1) and (2) alone. (By using concentrated urine, as few as 100 m u / l could be demonstrated.)

But in 1936 Hamburger pointed out the following data. The anterior pituitary hormone causes follicle-stimulation, whereas the main action of the chorionic hormone is in the formation of corpora lutea. Furthermore, Helga Gerber (Paris, 1933) had shown that seminomata produced either no hormone at all or a small quantity of follicle-stimulating hormone (F S H), whereas other tumours produced both F S H and the chorionic or luteinizing hormone. Zondek confirmed this in 1935, but doubted its diagnostic value. Hamburger's other point was that in cases of seminoma causing the excretion of F S H, the tumour itself was not shown to contain any F S H, the presumption being that the latter was produced in the pituitary. The effect of castration was also to cause an increase in F S H. Thus, Hamburger assessed the two

hormones separately and found in cases of seminoma only FSH, and low titres at that, whereas in other tumours he found chorionic hormone with titres mostly of a higher level. These are to be found in *Table IV* and are discussed later.

Ferris published in 1943 the results of a series of cases and claimed that neither the Aschheim-Zondek nor the Friedman test were as sensitive as the Frank test in which rats are used. He states that the Aschheim-Zondek test does not give positive readings below the equivalent of 66 rat units, and that the borderline of malignancy is 20 rat units/litre. He recommends routine testing for 25, 40, and 66 r u / l, claiming that the Frank test is sensitive down to titres of 5 r u / l. However, others report quantitative readings by the Aschheim-Zondek technique as low as 50 and 100 m u / l before the test becomes negative, and the borderline of malignancy does not appear to be substantially lower than these figures.

A number of investigators have concerned themselves with normal control observations, and also controls in cases of inflammatory or granulomatous lesions of the testis. Thus, in 1935, Cutler and Owen quote Zondek (1932) as having examined 40 normal cases and Ferguson (1933) 200 normal cases.

In their own paper, 13 normals showed titres all below 50 m u / l. Again in 1936, Cutler and Owen assayed 500 males with normal testes or benign lesions. All were negative. Higgins and Buchert (1939) quote Branch (personal communication cited by Ferguson) and report assays on 500 men, in which only 2 cases excreted hormone, these being 2 cases of teratoma. Read (1939), however, suggests that the castrating effect of disease in testes may exert some influence on the gonadotropin output. Ferguson (1931) reports 24 benign lesions—all negative, 15 carcinomatous patients with normal testis—all negative, and 12 cases of teratoma testis, giving 9 positive assays and 3 negative (the latter three had been cured of their disease). McDougall and Graham in 1943, however, quote 3 cases of parotid tumour (100 to 150 m u / l, 1 case of testicular gumma (for years 1000–2000 m u / l post-operatively) 2 cases of hæmangioma (200–500) and 1 case of undescended testis (pre-operatively 200, one year later 1000 m u / l. Acromegaly has also been reported as causing an increase in hormone output (Herger and Thibandear, 1943). They conclude that conditions other than teratoma of the testis may cause an increase in hormone output, but this is usually of a low level.

#### Views on the Value of the Test —

1 All are agreed that the test, in conjunction with other factors, is a valuable aid to diagnosis. With the exception of a few dissenters, notably McDougall and Graham (1943), Barringer, quoted by these authors, and Rosenblatt (1942), there is general agreement with Ferguson's view—namely, that hormone output tends to vary indirectly with the degree of cellular maturity of the tumour. Thus, maximum output (mostly from 10,000 to 200,000 m u / l) is achieved by chorionepitheliomatous types of growth, and the minimum (mostly 0–500 m u / l) by the adult type teratomata (*see Table II*). Perhaps, as Read (1939) comments, there is generally "not such clear distinction" as Ferguson found, but, on the whole, one is probably on safe ground in making

this general deduction. Ferris (1943) simply states that all malignant tumours cause the excretion of excessive amounts of hormone.

2 To accept the above as a rule of thumb, however, is not justifiable, as the figures show so much overlap, and there are too many exceptions to the rule. In the light of our present knowledge, and the limitations of the test, one cannot foretell the histological type of the tumour from bioassay of the urine alone (McDougall and Graham, 1943, Twombly et al 1942, Rosenblatt, 1942).

3 As to prognosis, the constant association of high titres with high degrees of malignancy and fatal outcome is most impressive. Twombly, Temple, and Dean (1942), who spent eight years collecting 203 patients and analysing the prognosis of 47, state that there was correlation between hormone levels and clinical course.

Consistently high levels tended to fatal outcome. In July, 1939, of 203 patients collected from 1931–1939 —

Those with	1000 m u / l or less had	33 per cent mortality
" " 1000–2000 m u / l had	57 per cent	"
" " 2500 m u / l or above had	82 per cent	"
" " 10 000 on more than 1 test had	100 per cent	"

Cutler and Owen (1935) concluded that the test was of value in diagnosis and prognosis in 66 cases. Ferris (1943) thought 20 rat units was the dividing line between normal and excessive amounts. Ferguson (1933), in his study of 117 cases, concluded that teratomata titres varied from 50–50,000 depending on embryonal character of the tumour, extent, and "status as regards treatment". Hamburger attached "great prognostic significance" to the test. It cannot, however, be said that low titres have invariably better prognoses (*see below*, under next paragraph), but one has the definite impression from the literature that the lower readings given, for example, by seminomata appear to imply a somewhat brighter future (Powell, 1938, Hinman and Powell, 1938, Hamburger, 1936, Twombly et al, 1942). But McDougall and Graham (1943) conclude that the test is no indication of malignancy, prognosis, or effect of treatment.

4 The significance of a negative reaction in a case of suspected tumour of the testis is a thorn in the diagnostician's side. There are abundant examples of negative assays being consistent with malignancy. This is found in many cases of seminoma and in some cases of other malignant growths. In McDougall's series of 36 pre-operative estimations, 25 per cent of the negatives had proven malignancy. Owen and Cutler (1936) consider that patients with teratoma excrete more than 100 m u / l in general. False negatives and false positives occurred in 10 per cent of assays. Stevens (1940) remarks "if the urine of a man with a testicular tumour contains 50 r u / l, or less, it is considered either a benign tumour of a seminoma, 30 per cent of seminomas gave a negative test in Hamburger's series".

5 What is the value of the test as an indication of the effectiveness of treatment? Most authors are agreed that the value is not inconsiderable. Ferguson concluded that when the output dropped to less than 400 m u / l within two weeks of the completion of treatment, the prognosis was good.

Irradiation caused a decrease in output, and local recurrence was heralded by an increase often before it became clinically recognizable. That surgery or irradiation caused a decrease in output accompanied by an improved prognosis was confirmed by Cutler and Owen (1935, 1936), who also found that a rising or stationary titre after treatment was a bad omen, such a rise being attributable to local recurrence or metastasis. Ferris (1943) quotes Cabot and Berkson (1939), *New Eng J Med*, as giving these figures —

Seminomas without metastasis	alive	10 yr or more post-operative	50.5 per cent
"	with	"	37.5 "
Other tumours without	"	"	35 "
"	with	"	10 "

(These figures are considerably higher than those given by Higgins and Butcher (1939), who found in 83 patients with malignant tumours of the testis that those without clinical evidence of metastases when first seen had only a 30 per cent five-year survival rate, 9 per cent survived 10 years. Most other writers (Tanner, 1922, Hinman, 1933, Young, 1926, Dean, 1934), quoted by Higgins and Butcher, give round about a 20 per cent or less five-year survival rate for all tumours, although Payne (1938), in a five-year follow-up gives 15 out of 38 as being alive after that time.)

Both Ferris and Hamburger found seminomas more susceptible to irradiation. The latter concluded that these tumours were less malignant and had better prognosis, whereas the remainder were mostly resistant to irradiation, having a bad prognosis. Powell (1938), and Hinman and Powell (1938), conclude that persistence at or above 500 m u / l indicates residual metastatic tissue, but not necessarily active tissue. The disappearance of the hormone was not nearly so significant as its persistence at abnormally high levels. Such persistence (400 m u / l indicated unquestionably that residual neoplastic tissue was present, while the disappearance of the hormone did not always mean the absence of malignant cells. The figure quoted coincides

**The Limitations of the Test**—In its present stage the test is subject to difficulties of interpretation, and the figures in *Table I*, showing as they do a considerable overlap, must not be accepted rigidly for these reasons —

1 The technique of extracting the hormone varies: untreated urine, alcoholic extraction, and the benzoic acid floc method are three examples. Again, accuracy depends on the number of mice used per level of assay. Rats and rabbits are used by some.

2 Interpretation of the ovarian changes is empirical and variable. This has been discussed already.

3 Obviously the titre must vary directly with the mass of the growth, or that portion of a mixed growth producing the hormone. Further, a small primary with a small secondary might produce a lower titre than a single operable primary, in which the prognosis, estimated pre-operatively on a hormonal basis might appear to be worse than in the former case.

4 By no means all of the figures in *Table I* represent pre-operative titres.

5 Some authors assay 'morning urine', others, more accurately, use 24-hour specimens, thus ruling out renal sources of error.

An abstract of the above figures is given below in *Table II* alongside the figures given by Ferguson, with which they are interesting to compare. It is seen that there is general agreement with the latter's findings. In the present stage of the test, however, there are very few grounds for attempting to foretell the histological type of the tumour from an assay of the urinary hormones.

Table II

ABSTRACT OF TABLE I			FERGUSON'S FIGURES		
No of Cases	Histological Type	M U / L	No of Cases	Type	M U / L
15	Choriomorphomatous	10,000–200,000 50 per cent above 50,000	1	Choriomatous	50,000 and over
15	Miscellaneous or mixed teratomas	500–50,000	7	Adenocarcinoma	1000–40,000
63	Adenocarcinomas	100–50,000 30 per cent less than 2000			
81	Carcinomatous types	0–10,000 70 per cent 2000 or less	15	Carcinoma	2000–10,000
39	Seminomas	Average less than 1000 75 per cent less than 500	10	Seminoma	400–2000, average 1000
18	Mixed, with adult types	0–1000 60 per cent less than 500	5	Mixed, with adult types	50–500
	Purely adult	55 per cent less than 100			

with that mentioned by Ferguson, below, which, within two weeks of treatment, a favourable prognosis might be expected.

McDougall and Graham, however, concluded that post-treatment levels of hormone were no help as a guide to treatment. They might increase appreciably in 75 per cent of cases. Only 6 out of 23 living patients returned to less than 200 m u / l, whereas 4 out of 23 who died also returned to this level.

It is seen from *Table II* that urinary hormone assay provides a basis for dividing the tumours into three main groups as has been done in *Table III*. Apart from the rare dermoid cyst, there is a relatively benign\* group of adult or near-adult tumours.

\* The purely benign tumour of the testis is a rarity. The group is described as 'relatively benign' so as to contrast it with the embryonal teratoma, which is notoriously malignant.

('mixed adult teratoma') producing, in 60 per cent of cases, less than 500 m u /l, of which the 'adult' type were in 55 per cent of cases producing less than 100 m u /l. Then there is the next group comprising what most observers are content to call 'seminomata', giving somewhat similar titres (but higher if one includes 'carcinoma-seminomas', of which 80 per cent are 0-2500 m u /l). Then, finally, there is

al (1942), point out that simple alcoholic extraction may not take up all the hormone

c It is presumed that while estimating chorionic hormone on the basis of the occurrence of hæmorrhage and luteinization of the follicle (follicle enlargement on its own merely indicating the presence of FSH), the quantitative result is bound to be lower than if "gonadotropin" (i.e., both FSH and

Table III

TUMOUR	SUGGESTED CLASSIFICATION	M U /L
Cystic teratoma or dermoid	Dermoid cyst (benign)	
Adult or mixed teratomas	'Mixed adult teratoma', benign or malignant	0-1000 60 per cent are less than 500 Of adult types, 55 per cent are below 100
Seminoma	Seminoma, malignant	Average level well below 1000 75 per cent are below 500 Only 25 per cent are below 100
Chorionepithelioma, adenocarcinoma, carcinoma, malignant teratoma, all types	'Embryonal teratoma', malignant	1000-50 000 1-3 millions in extreme cases

the group ('embryonal teratoma') comprising choriomatous, adenocarcinomatous, carcinomatous, and 'malignant teratomatous' types, forming the upper level of excretion at a range of 1000-2000 units up to 50,000 and more, being in extreme cases up to 1,000,000 and 3,000,000

In Table III the tumours considered are unified under three main headings, constituting a simplified classification

This brings us to Hamburger's figures (Table IV), which were not included in Table I since, for

chorionic hormone) is assessed singly on the basis of any of the three changes in the ovum, as in Ferguson's interpretation

d Hamburger's figures are compiled from assays after removal of the primary tumour in most cases

## DISCUSSION

Briefly, then, the position is this —

There appear to be two hormones, A and B, in the urine of patients with tumours of the testis. Hamburger's work suggests that seminomas are

Table IV\*

No	HISTOLOGY	M U /L
7	Seminoma	None demonstrable
10	"	100-400 Mostly less than 200 FSH
4	Mixed epithelioma*	20,000 or over chorionic hormones
1	" "	100-300 " "
1	" "	50 " "
1	" "	100 " "
1	" "	100-150 mixed hormones
1	" "	3000 chorionic hormones
1	" "	200 " "
1	" "	None demonstrable
1	Teratoid, benign	50-100 FSH

\* [Excluding 1 case of seminoma giving 100-25,000 over various assays. Unlike all the other seminomas, this one resisted X rays. One case of mixed epithelioma ('embryonal teratoma') gave 20 000-50,000 (Case 16), and photographs published by Hamburger showed chorionic tissue mixed with other histological types.]

reasons stated earlier, interpretation did not afford a basis for general comparison

Thus seminomas were either negative or mostly less than 200 m u /l, and 'mixed epitheliomas' were mostly (65 per cent) at or above 200 m u /l varying up to over 20,000 m u /l in a case with choriomatous tissue. These figures are on the whole lower than those in Table I, and the following reasons may help to account for this —

a Where there are no demonstrable hormones, Hamburger points out that this does not imply that the normal output is not exceeded. It is possible that the test is not sufficiently delicate

b In fact, the test is performed either on "untreated urine", or after "alcohol precipitation after the Bidel-Zondek method". Again, Twombly et

responsible for small amounts of A, producing reactions (1) and (2), and teratomas for larger amounts of B plus A, producing reactions (1), (2), and (3). It is thus essential to assay both hormones separately if the test is to be of any real scientific value. Ferguson and his followers have not taken this into account, having simply assayed total hormones on an empirical basis, and constructed a loose sliding scale of mouse units to correspond with the pathological differences between the particular neoplasms. The presence of reaction (3) is here taken to indicate a five-fold multiple of the titre required to produce reactions (1) and (2). The qualitative difference involved here is thus ignored. There appears to be little scientific rationale to justify this latter interpretation, and



although Ferguson's work anteceded that of Hamburger by three years, it is difficult to understand why subsequent observers appear to have brushed aside Hamburger's facts, although these have been stressed by Twombly (1942), and mentioned by Ferris (1943)

It would seem, therefore, that a very good case exists for attempting to confirm the existence of the two urinary hormones, assaying them separately, and finally assaying the tumours themselves in every case. In this way it could be ascertained whether in fact seminomata cause only FSH to appear in the urine but not in their own tissue, whereas embryonal teratomas cause both hormones to appear in the urine and probably play a part in the elaboration of chorionic hormone actually in their own tissues. Titres estimated by this method could then be compared with another scale of readings produced by assaying the hormones together after Ferguson's interpretation, and the results could be compared. (It is interesting to note that Beilly et al (1940) found in a teratoma 142 m u of FSH and 43 m u of chorionic hormone per gramme of tumour.) If Hamburger's premises were confirmed then an adjustment of technique and interpretation might bring a greater degree of uniformity into the results of urinary hormone assay, and the three groups of tumours might become better defined hormonally, though this would not alter the effect of variations in the size of tumours, or the fact that one embryonal teratoma might contain a preponderance of choriomatous tissue, giving a high titre, whereas another might be predominantly carcinomatous, giving a lower titre.

**Comments on Technique**—Owen and Cutler (1937) suggest that the benzoic acid floc technique is preferable if the urine contains toxic substances. Also they claim (1935) greater accuracy where small amounts of hormone are concerned by a modification of the benzoic acid technique of Doisy and Katzman. Twombly et al (1942) notes that alcoholic extraction gives a varying yield of hormone, and stresses the need for more mice per assay for each given level of hormone. Ferris (1943) considers the Frank technique most suitable, and suggests routine testing for 25, 40, and 66 m u/l.

**Treatment**—Tanner's collection of 465 simple orchidectomies without X rays had only 5½ per cent four-year survivals (quoted by Roche, 1933).

Irradiation and orchidectomy are the surgeon's weapons. Orchidectomy alone provided 24 per cent of the five-year survivals in Higgins and Buchert's series (1939), whereas orchidectomy plus X rays provided 35.5 per cent. The question is whether irradiation should precede as well as follow operation. McDougall and Graham (1943) suggest that the effect of irradiation is useful as an adjunct to diagnosis. A theoretical advantage is that if such treatment causes a drop in hormone output, the diagnosis is confirmed and the risk avoided of operating on an inflammatory lesion. This would appear to have little advantage besides delaying surgical removal of a tumour probably of great malignancy. A disadvantage is that pre-operative irradiation distorts the histological picture.

It would appear reasonable to perform simple orchidectomy as the operation of choice (Roche,

1933) immediately the diagnosis is made (or to explore if in doubt) and follow up routinely with irradiation, especially of the aortic glands whether or not metastases were suspected. This routine would cause fibrosis of the lymph-drainage system, thus avoiding the spread of a possible local recurrence subsequent to treatment.

The five-year survival rate may be misleading as an index of final cure. A case is reported (Zerman, 1943) of recurrence after 11½ years of a tumour treated by orchidectomy and irradiation.

## CONCLUSIONS

1 The quantitatively adapted Aschheim-Zondek test in cases of malignant disease of the testicle has considerable value.

2 There is need for a standardized technique, embracing many improvements suggested in the literature. These refer to extraction of the hormone, exclusion of renal factors by taking 24-hour specimens, routine assay before treatment and serially during and after treatment, use of more than one mouse per level of concentration, further inquiry into the nature and effects of the urinary hormones with a view to obtaining uniformity of interpretation of the test, histological section of the mouse ovary after the test, bioassay of the tumour itself and estimation of the two hormones separately if such duality can be confirmed.

3 The limitations of the test hitherto are based mostly on the lack of the above uniformity of technique. It is thus to be expected that the collected figures in Table I show considerable overlap and variation. It must not, however, be expected that clear-cut definition of the three main types of tumour will be forthcoming on a hormonal basis. Variations must occur where there are differences in the bulk of the primary and when there are metastases. Again, the enormous variation in the histopathology of the embryonal teratoma group cannot make for uniformity in quantitative hormone output.

4 The figures collected show that over a large number of cases the range of titre is characteristic for each of the three main groups—the 'embryonal teratoma', the 'seminoma', and the 'mixed adult teratoma', benign or malignant, but that the precise pathology of a particular tumour cannot be predicted from the pre-operative urinary assay. All that can be said is that high levels tend to suggest the more embryonic-cell type, while low levels suggest either the seminoma or the mixed adult type.

Serial tests during and after treatment are of value in that they may indicate satisfactory progress, local recurrence, or the advent of metastases. Such tests should be performed for at least ten years after treatment, first weekly, then gradually becoming less frequent, till an interval of not more than six months separates two consecutive tests.

## SUMMARY

Most of the available literature on the subject of hormonal tests in tumours of the testis has been reviewed.

The nature and limitations of the test have been discussed, with some suggestions for improvement and standardization. There is need for much more work to be done on the subject. The results of the



Aschheim-Zondek test in the hands of various workers have been collected and tabulated in over 300 cases

An attempt has been made to subdivide the tumours into three main groups

Prognosis and treatment have been briefly discussed

I am indebted to the Medical Director-General of the Navy for permission to publish this paper, and record my sincere thanks to Mr A E Roche, Dr R Welsh, and Professor Silverstein for reading the manuscript and providing helpful suggestions and criticism

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## CHRONIC HYPERTROPHIC ILEOCÆCAL TUBERCULOSIS, AND ITS RELATION TO REGIONAL ILEITIS (CROHN'S DISEASE)

By A W TAYLOR

ALTHOUGH there are earlier references to chronic granulomata of uncertain aetiology affecting the intestine in man, recent interest in the subject was aroused by a paper by Crohn, Ginsberg, and Oppenheimer, in 1932, in which these authors described a chronic inflammatory lesion of non-tuberculous origin affecting the terminal ileum, termed by them 'regional ileitis'. Since Crohn's original description, a voluminous literature, mainly in America and this country, has sprung up around the subject, and by 1937 over 200 cases had been recorded in America alone. Although Crohn originally described the disorder as affecting the terminal ileum, subsequent writers, and later Crohn himself, have recognized that the cæcum and ascending colon may also be involved. Crohn and most subsequent writers have insisted that regional ileitis is distinguishable clinically and pathologically from hypertrophic ileocæcal tuberculosis, and it is this claim which it is here intended to examine.

Turning to hypertrophic ileocæcal tuberculosis, we come to a clinical and pathological entity which has been recognized for many years. Here is no 'new disease', as regional ileitis has been termed (Barrington-Ward, 1938), but one which has become outmoded by its new and popular rival. So much so, indeed, that a leading text-book of general medicine states categorically that there is no evidence that this disease is tuberculous in origin, and that it is probably a form of regional ileitis (Price, 1941). Although not all modern opinion on the subject is quite as dogmatic as this, the increasing tendency

is to view with suspicion any diagnosis of hypertrophic ileocæcal tuberculosis.

Clinically, the two conditions have much in common. The age incidence is the same. Graham (1941), in a series of 35 cases of regional ileitis, showed that 74.3 per cent occurred in patients under 40, while Stewart (1927), in his series of 21 cases of hypertrophic ileocæcal tuberculosis, found that 80.9 per cent occurred in the same age group.

The clinical features of abdominal pain with nausea and vomiting, low-grade pyrexia, palpable mass in the right iliac fossa, obstructive symptoms, and finally sinus formation, are common to the two diseases. Both diseases commonly result in the presence of occult, and, rarely, fresh blood in the stools. Radiologically distinction is not possible, since, as will be seen, the intestinal lesions are indistinguishable, and therefore the mechanical effects are the same.

#### AETIOLOGY

Nothing certain is known of the aetiology of regional ileitis, and little is to be gained by recapitulating the numbers of almost entirely theoretical possibilities put forward by various authors. Of the more plausible suggestions, one may mention the dysenteric theory put forward by Felson (1935), who claimed to have isolated dysenteric organisms from the lesions, and to have demonstrated diagnostic agglutination titres in a series of cases. No subsequent investigation has confirmed these findings.

Reichert and Mathes (1936) in interesting experiments, using dogs as experimental animals, showed that the injection of sclerosing material into the mesenteric lymphatics will produce a chronic lymphœdema of the affected intestinal segment, with little or no tendency to resolution, and an associated hypertrophy of the muscle layers. There was, however, no associated inflammatory reaction, and no tendency to ulceration of the mucosa.

Bockus and Lee (1935) suggest that some anatomical peculiarity of the ileocæcal region may predispose to the development of chronic inflammatory lesions in this region from a variety of causes, all of which might give rise to a similar clinical picture.

Hadfield (1939) sees in the histology of the lesions a possible relationship to the equally mysterious sarcoidosis of Boeck. A tuberculous aetiology has by earlier writers been rejected, often without any evidence whatever, but more recently it has been shown (Pumphrey, 1938) that where a series of cases of regional ileitis is thoroughly investigated it is found that up to 20 per cent are proven tuberculous by careful histological examination and animal inoculation. With hypertrophic ileocæcal tuberculosis we are on surer ground, the histology is frankly tuberculous, although as Stewart (1927) emphasizes, it may be necessary to examine sections from several blocks before finding characteristic tubercles. Tubercle bacilli may be found in the lesions by appropriate staining methods, by culture, or by animal inoculation.

### **PATHOLOGY**

The macroscopical pathology of Crohn's disease and of hypertrophic ileocæcal tuberculosis resemble each other so closely that one description will suffice. The lesion affects the terminal ileum and commonly involves the cæcum and ascending colon. The essential lesion is seen in the chronic inflammation and thickening of the intestinal wall, resulting in stenosis of the affected gut. There is usually an associated ulceration of the mucous membrane and often a mesenteric lymphadenitis. In the case of hypertrophic ileocæcal tuberculosis, there may or may not be obvious subperitoneal tubercles over the affected gut, but as small subperitoneal nodules of similar appearance due to lymphoid collections or fibrous nodules may occur in Crohn's disease, the point is not of diagnostic value.

The histological picture of Crohn's disease is said to be that of a proliferative subacute or chronic inflammation: most authors stress the lymphoid overgrowth, with its many follicles, the germinal centres of which tend to be extremely hyperplastic. Added to this, there is always diffuse infiltration of all the layers of the thickened intestinal wall by eosinophils, lymphocytes, plasma cells, mononuclears, and polymorphs in varying proportions. Foreign-body giant cells are occasionally seen. As to the presence or absence of true tubercles, there is a remarkable lack of agreement in published reports. In a review of 21 cases from the Mayo Clinic, Coffey (1938) states that true tubercles are not seen in Crohn's disease and that their presence should suggest a tuberculous aetiology. On the other hand, in the case reported by Colbeck, Hurst, and Lintott

(1937), the histology is reported as being indistinguishable from tuberculosis.

Hadfield (1939) stresses the resemblance of the hypertrophied lymph follicles to the similar appearances seen in Boeck's sarcoidosis. The histology of hypertrophic ileocæcal tuberculosis is well known, every characteristic of tuberculous lesions is seen, and the only points worth bringing out are that caseation is not usually a prominent feature, and that the ratio of tuberculous to non-specific inflammatory change varies enormously from case to case. Stewart (1927) has pointed out that the whole affected gut wall may show no evidence of tuberculosis, but that related mesenteric lymph-glands may show active tuberculous disease.

### **CASE REPORTS**

*Case 1*—A man, aged 52 years, gave a history of lower abdominal pain over the previous 14 years, becoming more severe and spasmodic in nature during the past few weeks. There was a recent history of increasing constipation and some loss of weight.

On examination, a palpable tumour was felt over the line of the ascending colon. Fæcal examination showed occult blood present. X-ray examination showed a filling defect of the cæcum.

At operation (Nov. 17, 1943, Mr E. C. Hughes) the terminal ileum and cæcum were found thickened and inflamed, with tubercles on the peritoneal surface. The affected ileum, the cæcum, and ascending colon were excised and an end-to-end anastomosis made between ileum and transverse colon.

After operation, signs and symptoms of pulmonary tuberculosis appeared, and death from pulmonary tuberculosis occurred three months later. Autopsy was not performed. The resected gut showed much thickening and stenosis, with diffuse ulceration of the mucous membrane. Sections showed extensive tuberculous infiltration, with tubercle bacilli present.

*Case 2*—A woman, aged 21 years, was admitted on account of a severe attack of pain in the right iliac fossa. She had had similar attacks, usually associated with vomiting, during the previous year. A diagnosis of acute appendicitis was made, and at operation (April 23, 1943, Mr J. J. Bell) the terminal ileum, cæcum, and appendix were found to be bound down by adhesions; thickening and inflammation were seen, and tubercles were present on the peritoneal surface. The appendix was removed, and on section showed widespread infiltration of all its layers by typical tuberculous granulation tissue. Subsequent X-ray examination showed a filling defect of the cæcum and a loop of small gut adherent to the ascending colon. Radiograph of the chest showed suspicious mottling at the left apex.

The patient was discharged four months later in good condition. She was readmitted four months later still with recurrence of abdominal pain and a general deterioration of her general condition, and died July 5, 1944.

At autopsy, a generalized miliary tuberculosis was found. An old quiescent tuberculous focus was present at the apex of the left lung. The lower ileum showed an acute tuberculous ulceration. In addition, hypertrophic ileocæcal tuberculosis affecting the terminal ileum, cæcum, and ascending colon was found, with multiple adhesions and a small loculated area of tuberculous peritonitis.

Histological examination confirmed these findings. Tubercle bacilli were present in the lesions.

*Case 3*—A girl, aged 15 years, was admitted on account of swelling of the left knee and left wrist. She gave a history of attacks of abdominal pain during the month before admission.

While in hospital the joint condition subsided, but she suffered from a low-grade pyrexia, and the attacks of abdominal pain, usually peri-umbilical in position, became more severe and frequent. A palpable mass was found in the right iliac fossa and X-ray examination showed a filling defect of the terminal ileum. The faeces showed occult blood present. Mantoux test was negative in 1:100.

tuberculous in nature (Figs 211-213). Tubercle bacilli were found in areas of tuberculous granulation tissue in the mesentery.

## DISCUSSION

The three cases reported above exemplify clinical pictures associated with ileocaecal tuberculosis.

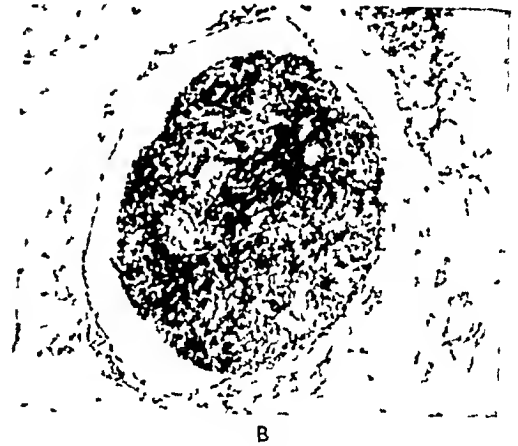


FIG 211—Mesenteric lymphatics in A, transverse and B, longitudinal sections showing invasion by tuberculous granulation tissue ( $\times 60$ )

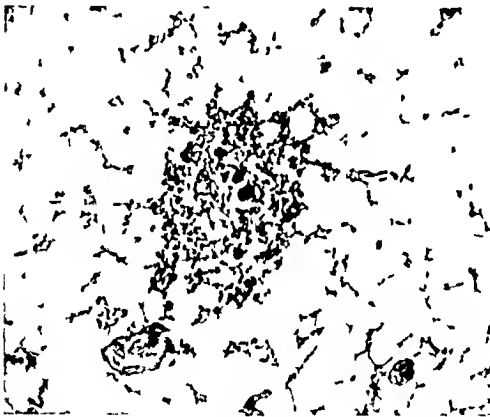


FIG 212—Invasion of smaller mesenteric lymphatics by tuberculous granulation tissue ( $\times 80$ )

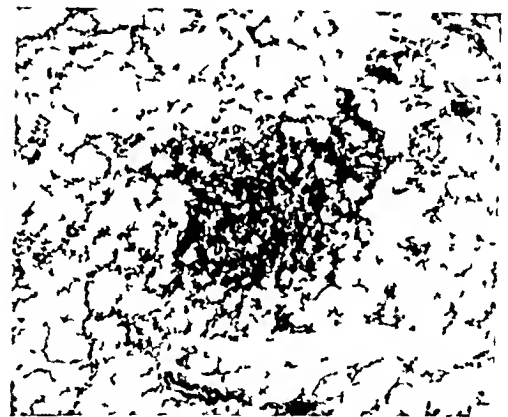


FIG 213—Complete occlusion of mesenteric lymphatic by tuberculous inflammatory reaction ( $\times 60$ )

At operation (Jan 21, 1945, Mr Hughes) a thickened, inflamed terminal ileum and caecum were found, with early changes of similar nature in the ascending colon. No tubercles were seen, but calcified mesenteric glands were found. Resection of the affected gut was performed and anastomosis of ileum to transverse colon was performed. On examination, the resected gut showed much thickening and inflammation of the wall, there was ulceration of the mucous membrane, and a pronounced mesenteric lymphadenitis. Several calcified glands were found. Histological examination of the affected intestinal wall showed the changes described as typical of Crohn's disease: there was much non-specific chronic inflammatory reaction with very marked lymphoid hyperplasia, and a diffuse infiltration by lymphocytes, plasma cells, and eosinophils. There was much dilatation of the lymphatics. Careful search through many sections showed occasional typical tubercles with endothelial cell reaction and giant cells present. Section of areas of the mesentery showed a striking lymphangitis, apparently

Cases 2 and 3 present the picture of severe abdominal pain clearly arising from the inflamed viscus and its peritoneal covering. Case 1, in which obstructive symptoms were associated with a palpable tumour in a man past middle life, simulated a carcinoma of the colon. All three were proven tuberculous in origin, two dying from pulmonary and miliary tuberculosis, and all three showing tubercle bacilli present in the lesions. It should be noted how closely the clinical pictures represented by these three cases resemble two of the classical stages of regional ileitis as described by Crohn, the rarer stage showing diarrhoea with blood and mucus, and the final stage of multiple fistulae, may also be exactly reproduced by ileocaecal tuberculosis.

Where two conditions mimic each other as closely as do these, clinical differentiation is clearly not possible, and this is not surprising since the

basic pathology is identical, giving the successive stages of inflammation and local peritonitis, ulceration of the mucous membrane, fibrosis, thickening, and stenosis of the affected gut, and finally fistula formation. The histological features of the three cases described above are of some interest, the first two were frankly tuberculous and tubercle bacilli were numerous in the lesions. There was, however, also much non-specific inflammatory reaction, and lymphoid hyperplasia with irregularly distributed follicles was also present. Considerable dilatation of the lymphatics was a striking feature. In the third case the picture was entirely different. Here chronic non-specific inflammatory changes with great lymphoid hyperplasia made up almost the whole picture in the affected gut wall. Again dilated lymphatics were prominent. But prolonged search revealed a very few typical tubercles with endothelial cells and scattered giant cells. Examination of the mesentery of the resected gut showed the picture of an advanced lymphangitis, with lymphatic channels occluded by tuberculous granulation tissue, ringed by lymphocytes, or completely replaced by fibrous tissue. In fact, inflammatory changes were, in the mesentery, entirely restricted to the lymphatics, and their tuberculous nature was much more evident in this site than in the gut wall. It was only in the mesentery that tubercle bacilli were demonstrated.

It is suggested that in this observation there is a clue to the nature of Crohn's disease. Reichert and Mathes (1936) showed that the hypertrophied gut wall is explicable on the basis of lymphatic obstruction in the affected segment. Maintenance of the obstruction, with the pronounced secondary inflammatory reaction, may well be caused by a low-grade tuberculous infection largely restricted to the lymphatic system, perhaps because of a high degree of tissue immunity. Where resistance is low, the tuberculous infection spreads diffusely throughout the gut wall, giving the picture of a florid ileocæcal tuberculosis. The two conditions of Crohn's disease and hypertrophic ileocæcal tuberculosis thus are probably different reactions of the human host to a single disease, and grade into each other.

Finally, let us examine the bacteriological side of this question. As was seen earlier, since neither clinical nor pathological criteria enable distinction to be made, it is only after a failure to detect tubercle bacilli in the lesions that a case should be labelled Crohn's disease. This has been admitted in a summary of the subject by Lintott (1938). Unfortunately, it is only in a small minority of recorded cases that this essential criterion has been applied. Technically the finding of tubercle bacilli in stained sections of tuberculous lesions is not always easy, and while a positive result is conclusive, a negative by no means excludes a tuberculous pathology. Animal inoculation is a more accurate test, but is not infallible, and in a study of the literature one is usually given no information as to the amount or nature of the tissue used, its preparation before inoculation, or the number of animals inoculated.

Where animal inoculation gives negative results, are we justified in stating that the lesion is certainly non-tuberculous? Case 3 in this series shows how scanty may be the tuberculous granulation tissue in the lesion and how it may largely be restricted to the mesenteric lymphatics, these features may be due in part to tissue resistance of the host and perhaps also to an attenuated tubercle bacillus which may not possess normal pathogenicity. The final stage may well be reached when the tuberculous lymphangitis has burnt itself out, leaving a thickened, scarred intestinal wall, obliterated mesenteric lymph-vessels, and the secondarily hypertrophied lymphoid tissue. Secondary infection of this deformed segment of gut is inevitable. It is thus quite understandable that in a proportion of cases of hypertrophic ileocæcal tuberculosis the lesions may show no evidence of a tuberculous aetiology.

It seems probable that Crohn's disease has had, as a new disease, too enthusiastic and uncritical a reception, and that hypertrophic ileocæcal tuberculosis has been too lightly discarded as a clinical and pathological entity. Tuberculosis, though not always of florid type, probably accounts for a much higher percentage of cases of regional ileitis than is at present recognized.

### SUMMARY

1 A review is given of the aetiology, pathology, and histology of Crohn's disease and hypertrophic ileocæcal tuberculosis.

2 Attention is drawn to the fact that it is impossible on a basis of clinical features or morbid anatomy to distinguish between the two conditions.

3 Three cases of hypertrophic ileocæcal tuberculosis are described.

4 A chronic tuberculous mesenteric lymphangitis is described in one of these cases. The wall of the affected ileum in this case showed the gross pathological and the histological features described as characteristic of Crohn's disease.

5 It is suggested that a similar chronic tuberculous lymphangitis of the mesentery may be the basis of many cases of regional ileitis where the lesions in the affected gut wall are apparently non-tuberculous.

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## SHORT NOTES OF RARE OR OBSCURE CASES

### INTUSSUSCEPTION OF THE SIGMOID DUE TO SIMPLE POLYPUS WITH ANNULAR CARCINOMA OF THE DESCENDING COLON

By B T ROSE, BIRMINGHAM

#### CASE REPORT

**HISTORY**—J L, aged 70, was seen with symptoms of subacute obstruction of three days' duration, associated with the passage of blood and mucus per rectum

difficulty, when it was noted that an annular carcinoma of the colon was present just below the splenic flexure (*Fig 214*). The sigmoid, descending colon, and splenic flexure were mobilized and resected by Paul's method



**FIG 214**—Showing the intestine, which has greatly shrunk in preservation and the incompletely reduced intussusception with the polypus and the adenocarcinoma of the colon (*Approximately one half natural size*)

An elongated tumour could be felt in the left iliac fossa, while per rectum a rounded swelling the size of a bantam's egg could be just reached with the finger

A diagnosis of intussusception of the sigmoid due to polypus was made

**OPERATIVE FINDINGS**—An intussusception of the whole of the sigmoid loop about 10 in in length was found. At the apex a large polypus could be felt. The intussusception was almost reduced with considerable

#### COMMENT

The association of multiple polypi with carcinoma of the colon is well known, but the single polypus in the writer's experience is also not infrequently found with a new growth of the colon

I am indebted to Mr W J Pardoe, of Birmingham, for the illustration

### DISCOLORATION OF THE ABDOMINAL WALL IN ACUTE PANCREATITIS

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THIS condition was first observed by Grey Turner in 1912 and published in 1920. Cullen in America both observed and published in 1918 an account of the umbilical discoloration in ruptured ectopic gestation. In English literature the terms Grey Turner's and Cullen's signs refer respectively to the condition each first described, while in American literature the term Cullen's sign includes both conditions

The illustration of umbilical and flank discoloration (*Fig 215*) was drawn from a case of acute pancreatitis on the ninth day of the disease

#### CASE REPORT

A female, aged 65, was admitted to Withington Hospital, Manchester, Dec 14, 1943, with upper abdominal pain of 16 hours' duration. The pain was sudden

in onset, continuous, intense, with maximum localization between the umbilicus and left costal margin, and radiating to the left costovertebral angle. Pulse 104, temperature 97°. Previous history: Gastrojejunostomy (duodenal ulcer) and appendicectomy, July, 1926

On the third day of the disease a discoloured area appeared on the skin around the umbilicus, on the seventh day a similar but smaller area was first noticed in the left flank. These areas, lacking uniformity in colour and showing an admixture of distinct blue, green, and yellow elements, resembled exactly the colour changes in a fading ecchymosis. A diagnosis of acute pancreatitis was made. Urinary diastatic index 12, 6600 units in 24 hours. Serum lipase 0.35 units

On conservative treatment the signs and symptoms diminished in intensity with the formation of a well-localized mass in the left hypochondrium. This mass was drained through a small incision over it. Both oblique and transversus muscles were found to be

permeated with dark red blood. On incising these structures a cavity containing 3 oz of blood-clot was immediately entered. A rubber tube was inserted. Pathological report on the blood-clot: "Blood-clot shows increased lipase activity. Inoculation of clot into ethyl butyrate hydrolyses five times as much as is hydrolysed by normal clots." The convalescence was uneventful.

### DISCUSSION

The discoloured areas have been variously reported as bluish, dirty-greenish, and yellow. Fallis (1937), amongst others, suggests that the

method of spread. The last is described as being limited above and below the umbilicus by the suspensory ligament and urachus respectively, with a consequent tendency to pool in the potential sub-umbilical space where there is direct contact with the subcutaneous tissue owing to the absence of the fascia transversalis. Fallis has described 2 cases of acute pancreatitis with umbilical discoloration but without a blood-stained peritoneal exudate—strong evidence, to which this case adds further support, in favour of the extraperitoneal method of spread.

FIG 215 —Showing the discoloration around the umbilicus and in the flank in a case of acute pancreatitis

discoloration resembles an ecchymosis in that the colour is at first blue-black, then green, and finally yellow before disappearing.

The importance of the sign lies in the diagnostic value, its interest in its aetiology. The flank discoloration is universally agreed to be due to direct extraperitoneal spread of blood and pancreatic secretion. The umbilical discoloration, however, has offered scope for much ingenuity in attempts at explanation, some of which are of extremely doubtful validity and anatomy. Grey Turner (1920) refers to the possibility of pancreatic secretions arriving at the umbilicus via the round ligament, while Fallis (1937) suggests abnormal apertures in the peritoneum, the rich anastomosis between the lymphatics of the subcutaneous tissue and those of the peritoneum, and finally an extraperitoneal

The incidence of umbilical discoloration is rare. This may be due to a pathological variation in the disease or to an anatomical variation at the umbilicus. Poirier (1912) describes the existence of a structure, the umbilical fascia. This is a thickening of the transversalis fascia. Levadoux (quoted by Poirier) observed it in 84 per cent of adults. Typically it completely or partially covers, and is firmly applied to, the umbilical ring. It may, however, more rarely occur as a band about the thickness of a finger, well above the umbilicus. In those cases in which the umbilical fascia does not constitute a complete covering for the umbilical ring, there is direct continuity at the umbilicus between the

extraperitoneal and subcutaneous tissues. This arrangement clearly favours umbilical spread of retroperitoneal changes.

It is a rational assumption that this anatomical variation in the presence of a retroperitoneal spread is one deciding factor in the development and incidence of umbilical discoloration in acute pancreatitis.

I am much indebted to Professor Wood Jones for the anatomical reference.

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## HERNIA TRAVERSING THE LESSER SAC

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### CASE REPORTS

THE first case to be described is one in which all but the terminal few inches of small intestine had herniated through an aperture in the transverse mesocolon, across the lesser sac of peritoneum, and returned to the general peritoneal cavity through the gastro-hepatic omentum.

#### Case 1—

HISTORY—J. W. A., male, aged 56 years, was admitted to St. James's Hospital on March 27, 1943. He gave a history of having four years previously and again for the last three weeks had attacks of epigastric gnawing



FIG. 216.—Reconstructed drawing of Case 1, showing the abnormal presentation of the small bowel in front of the stomach and colon.

pain two and a half hours after meals, relieved by taking food. Five hours before admission he was suddenly seized with a violent generalized abdominal pain. Just prior to the onset of pain he had vomited altered blood, but had not vomited since.

ON EXAMINATION—He was pale and appeared to be in obvious pain and very shocked. The temperature was subnormal, pulse-rate 100 and of irregular rhythm, and the respiration-rate 20. The respirations were entirely thoracic. There were moist sounds at the base of the right lung, the heart-sounds were distant and irregular. The abdomen was of board-like rigidity and very tender all over. Normal liver dullness was present.

Perforation of a peptic ulcer was diagnosed and he was operated on shortly afterwards.

AT OPERATION—Under general anaesthesia a right upper paramedian incision was made. Free gas and chyme escaped on opening the peritoneal cavity. A gastric ulcer situated on the posterior part of the lesser curvature was found, deeply penetrating the pancreas, and with a perforation into the peritoneal cavity about 1 cm. diameter at its lower edge. It was now noted that this would have been a perforation confined to the lesser sac but for the fact that the gastro-hepatic omentum was deficient. Further examination revealed the surprising appearance of the small intestine and its mesentery passing over the lesser curvature and anterior surface of the pyloric antrum, so that part of the stomach, transverse colon, and great omentum were obscured by it (Fig. 216). The duodenojejunal junction appeared to be pulled high up and there were adhesions in its neighbourhood. The distal ileum was seen to pass back over the lesser curvature of the stomach, through an opening in the transverse mesocolon, and then straight to the ileocaecal valve, this part of the bowel appearing a little tense. The caecum was drawn towards the opening in the mesocolon. There was no evidence of any obstruction and so it was decided not to reduce this hernia as it was obviously not the cause of his condition—indeed, only a cursory examination was made at this time. In view of the history of recent haematemesis, the whole ulcer was separated from the pancreas by pinching it with the fingers, the ulcer edge trimmed, and the now very wide completely penetrating ulcer closed, first with interrupted sutures placed deeply with the intent of obliterating any open vessel in its edge, and then by a second continuous seromuscular suture placed over this. After aspirating the peritoneal fluid a drainage tube to the pelvis was inserted through a suprapubic stab wound and the abdomen closed in layers.

PROGRESS—An intravenous saline and plasma drip was given after the operation. For two days the patient made normal progress, but then signs of general peritonitis and circulatory failure became evident and he died on March 30.

AT AUTOPSY—On March 31 Dr. Allen P. Piggot made a post-mortem examination. No cardiovascular abnormality was found apart from a few patches of aortic atheroma. There were patches of bronchopneumonia in both lungs.

Examination of the peritoneal cavity revealed a plastic general peritonitis. In the stomach was an ulcer 3 in. by 2 in., oval in shape, with two thrombosed vessel ends in its base. The sutures closing the perforation were intact. The site of pancreatic ulceration was noted.

The whole of the small intestine from duodenojejunal junction to just over three inches from the ileocaecal valve passed through a smooth-edged opening in the transverse mesocolon to the left of the middle



colic vessels, under the colic arch and 4 in by 3 in in diameter. The small intestine and its rather abnormally long mesentery passed behind the stomach, over its lesser curve and through a wide defect in the gastro-hepatic omentum and down in front of the pyloric antrum and colon. One coil of bowel was adherent to the site of the gastric perforation and all was covered with fibrinous exudate. There was no evidence of any intestinal obstruction.

The second case to be described, which followed a posterior gastrojejunostomy, is one in which the whole of the small intestine from stoma to within a few inches of the ileocaecal valve had herniated through the transverse mesocolon, across the lesser sac, and returned to the general peritoneal cavity through an opening on the left of the gastrocolic omentum.

#### Case 2—

**HISTORY**—J. M., male aged 61 years, was admitted to St James's Hospital on March 1, 1945. He gave a history of dyspepsia since 1923. In 1928 he had a gastrojejunostomy performed for duodenal ulcer at a London hospital. For six months after this operation he had repeated attacks of vomiting, but these gradually diminished in severity and he attained some degree of comfort. About 1938 he began to develop periodic bouts of pain in the right hypochondrium, worse at night, on stooping, or after meals. There was some relief by taking alkaline powders. He had a course of medical treatment for this in June, 1944. Just prior to admission he had had very severe pain.

**ON ADMISSION**—He was fairly well nourished. Examination of the abdomen disclosed a well-healed right paramedian scar, and tenderness on palpation just below the umbilicus.

On gastroscopic examination, the gastroscope entered a posterior gastrojejunostomy stoma, and an ulcer was seen on its margin.

Radiography of a barium meal showed a deformed duodenum and deformity in the region of the stoma. Much of the barium left via the duodenum and it was seen that the jejunum immediately proximal to the stoma was very dilated.

Surgical treatment was considered advisable, and when the patient's general condition appeared to be at its best, operation was undertaken.

**AT OPERATION**—Under local and light cyclopropane anaesthesia, the right paramedian incision was re-opened and a moderate number of adhesions were divided. A remarkable appearance was now seen (Fig 217). There was an opening to the left of the gastrocolic omentum through which the dilated afferent loop of a posterior gastrojejunostomy could be seen, which was rather high up the body of the stomach and near its greater curve. On the gastrojejunostomy was seen a congested scar. The efferent loop of the anastomosis passed forwards through the opening in the gastrocolic omentum and then down in front of the colon and great omentum. It was several moments before it was realized that nearly the whole of the small bowel was herniated through this opening and the afferent loop of the herniated bowel passed up behind the efferent loop and through the gastrocolic omentum opening, through lesser sac and transverse mesocolon, straight to the ileocaecal valve. The edge of the opening in the transverse mesocolon was only partly adherent to the small bowel and not at all to the stomach.

Further examination showed stenosing inactive anterior and posterior duodenal ulcers with prestenotic diverticula.

The small bowel was now reduced through the lesser sac to its normal position. The gastrojejunostomy was undone and the jejunum repaired. The opening in

the transverse mesocolon was closed. As it had been noted that the gastric mucosa was thick—and thus probably prone to recurrent ulceration—a high antecolic Hofmeister type of partial gastrectomy was performed, transecting

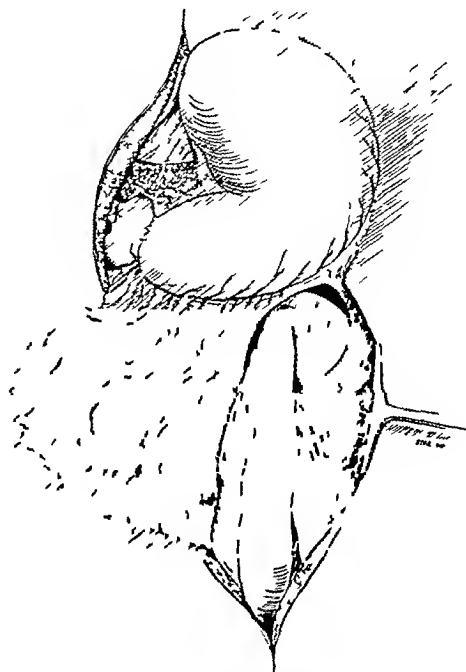


FIG 217—Reconstructed drawing of Case 2, showing the abnormal presentation of the small bowel in front of the colon and gastrocolic omentum.

the duodenum opposite the duodenal scars and anastomosing the stomach to jejunum well caudal to the site of the previous stoma. The abdomen was then closed.

The patient has made a good recovery from the operation.

#### COMMENTARY

In Rendle Short's series (1915, 1924) of internal herniae only 17 passed through the transverse mesocolon.

The cause of herniation through the transverse mesocolon, excepting that type which follows surgically made openings in it, is uncertain. It is to be distinguished from the congenital hernia between the layers of the transverse mesocolon—that is, the true mesocolic hernia (*recessus intermesocolicus transversus*) (Moynihan and Dobson, 1906)—but Schwalbe (1904) and Chalmers (1905) suggest that it may result from this form by rupture of the division between mesocolic hernia and lesser sac. The general consensus of opinion is that it is acquired. It appears to the left of the middle colic vessels and under the colic vascular arch (such an opening has rarely been noted without any bowel going through it). In this region the mesocolon is tenuous and of poor blood-supply. Hernia through the transverse mesocolon into the lesser sac may follow the operation of posterior gastrojejunostomy, but it is now much less common than formerly as the importance of taking the precaution of suturing the margin of the opening in the mesocolon to the stomach is now universally appreciated (Mayo et al, 1940). It is possible that in the second case described this type of hernia was produced by a

rather high gastrojejunostomy performed in the presence of gastric distension, so that when the stomach became reduced in size with freer emptying the stoma was pulled upwards and with it the small bowel was pulled into the lesser sac

In the event of bowel entering the lesser sac through the transverse mesocolon it may remain there—or pass between the leaves of the great omentum if these are incompletely fused. The bowel may, however, re-enter the peritoneal cavity by perforating the gastrohepatic omentum, the gastrocolic ligament just below the gastro-epiploic arch, or the great omentum. I can find no record of it re-entering by passing through the foramen of Winslow, though this seems a possibility.

Re-entrance to the general peritoneal cavity through the gastrohepatic omentum is very rare, but J Hogarth Pringle (1919) described 2 such cases in his own practice and quoted 1 case operated on by W J Mayo. It is interesting in view of the perforated gastric ulcer and hæmatemesis in the first case here recorded to mention that Mayo's case also had a gastric ulcer, and both of Pringle's cases had a history of dyspepsia and hæmatemesis though no ulcer was found in the latter two at laparotomy.

As the gastrohepatic omentum is even more tenuous than the transverse mesocolon, it is not surprising that it is a route for the re-entrance of the bowel to the general peritoneal cavity, and herniæ which gain entrance to the lesser sac by the

foramen of Winslow may leave it by this route (Edwards, 1943). An opening in the transverse mesocolon may also act as a route for re-entrance of bowel to the general peritoneal cavity, in cases where some other route of entry to the lesser sac is present.

It is possible that in the first case described the posterior ulcer may have attached itself at some stage to the transverse mesocolon, pulled it out in a diverticulum which became filled with small bowel, and later the diverticulum burst into the lesser sac. Occasionally a dimpling of the mesocolon is seen as a result of adhesion to a gastric ulcer. On the other hand, the dyspepsia or even the hæmatemesis may result from the hernia, for a history of dyspepsia is not unusual with hernia into the lesser sac no matter what route of entrance to it the bowel may take.

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## CARCINOMA OF THE SMALL INTESTINES

By B T ROSE, BIRMINGHAM

### CASE REPORT

**HISTORY**—A man of 59 years of age was admitted with a history of four months' colicky abdominal pain with occasional attacks of vomiting. Examination of the abdomen showed some distension with well-marked laddering and visible peristalsis over the whole abdomen. The large intestine did not appear to be distended.

duodenojejunal flexure. The small intestine above the growth was greatly dilated and hypertrophied, while below the obstruction dilatation and hypertrophy were also present for at least another 10 ft, gradually tailing off so that the lower ileum was of normal texture and size (Fig 218). No other growth was found in the rest of the intestinal tract. Primary resection of some 10 in. of intestine was carried out with ease.

Pathological examination showed the growth to be an adenocarcinoma with much interstitial fibrosis.

**Comment**—Carcinoma of the small intestine is rare, but the curious

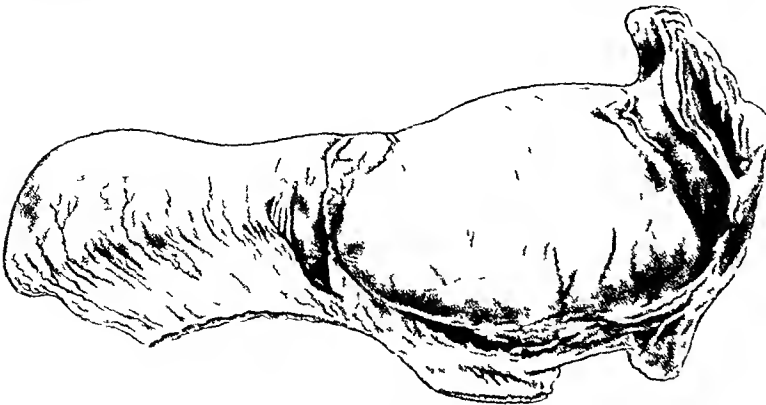


FIG 218—Showing the annular growth with dilated and hypertrophied intestine above and below it (Approximately one half natural size)

feature in this case was the hypertrophy and dilatation below the obstruction, which accounted for the general laddering seen over the whole of the abdomen.

Very careful examination of the alimentary tube was made for any further block, and none was present.

A diagnosis of subacute intestinal obstruction was made, with the ileocaecal region as the probable site of the obstruction.

**OPERATIVE FINDINGS**—At laparotomy an annular carcinoma of the jejunum was found 2 ft from the

I am indebted to Mr W J Pardoe, of Birmingham, for the illustration.

## HERNIA OF THE ILEUM THROUGH A HOLE IN THE TRANSVERSE MESOCOLON

### REPORT OF A CASE WITH SYMPTOMS AND RADIOLOGICAL APPEARANCES SIMULATING A MECKEL'S DIVERTICULUM

By RODNEY SMITH, MAJOR, R A M C

HERNIATION of the small intestine through a hole in the mesentery of the large or small intestine has been recognized as a possible cause of intestinal obstruction since Treves called attention to the occasional occurrences of such holes in the mesentery of the terminal ileum in 1885. Dolton (1944), in a review of the 76 cases previously recorded, discussed fully the questions of aetiology and symptomatology, and stated "the condition always presents as an acute intestinal obstruction without any specific symptoms or signs. Rarely is there previous suggestive history." He went on to describe the four cases in which previous signs had been suggestive. The case about to be described is remarkable in that the mesenteric hole was in a most unusual site and in that although suggestive

of "omphalomesenteric abscess" had been made, that the abscess had been incised and found to communicate with the abdominal cavity through a hole in the linea alba, that this hole had been curetted and not enlarged, and that exploration of the abdomen had not been undertaken. Spontaneous healing had occurred. Since discharge from this hospital the patient had had four attacks of abdominal pain with vomiting. In each attack typical small-gut colic had occurred intermittently over a period of several days and had been accompanied by fairly severe vomiting, marked abdominal distension, anorexia, and general malaise. The patient was normally of irregular bowel habits and often had no bowel action for several days. He did not associate any marked increase or decrease in constipation with the attacks of pain. There had been no bleeding per rectum, no disturbance of micturition, and no other significant symptoms in the history.



FIG 219—Radiograph taken 2 1/2 hours after a barium meal, showing a sausage-shaped segment of small intestine filled with barium and with a blind end pointing to the umbilicus.

signs were certainly present they were strongly suggestive of an entirely false diagnosis.

#### CASE REPORT

**HISTORY**—C. C., a Cypriot of 30, was apparently in fair health until eight months before admission to hospital. Minor attacks of abdominal discomfort before this date were considered to be of very doubtful significance. Eight months before admission he had been admitted to another hospital with an abscess of the umbilicus and had undergone an operation. Inquiry elicited a medical report giving the information that at this hospital a diagnosis



FIG 220—Radiograph at the end of 5 hours. The segment of small gut is still filled, and the large intestine clearly outlined and distinct from it.

**ON EXAMINATION**—No abnormal physical signs were found on general examination, examination of the abdomen, or per rectum, apart from a healed vertical scar, 4 in. long, running through the umbilicus.

The nature of the acute attacks, however, appeared diagnostic of some form of intermittent obstruction of the lower small intestine, while the previous history suggested strongly that the gut might be anchored to the umbilicus by an embryological band with or without a Meckel's diverticulum, a state of affairs commonly associated with obstruction. A radiological examination by following the progress of a barium meal through the gut was performed with the object of determining the

presence or absence of any localized hold-up and with the possibility in mind of visualizing a diverticulum. Nothing abnormal was seen in the stomach or upper part of the small gut, and the first abnormal picture was obtained at 2½ hours (*Fig 219*). In this picture it will be seen that the barium has filled a sausage-shaped segment of small intestine which appears to have a blind end pointing to the umbilicus. *Fig 220* shows the appearance at 5 hours, with the segment of gut still filled and the large gut well outlined and distinct from it. Subsequent examination showed that the segment had emptied completely of barium and could no longer be seen.

Discussing the diagnosis with Major J F Grant, R A M C, to whom I am indebted for these unusual radiographs, in spite of the clinical history strongly suggestive of a Meckel's diverticulum and the radiological appearance of just such a blind diverticulum, we were neither of us happy about making a certain diagnosis owing to the extraordinarily high situation in the abdomen. On the other hand, a connexion with the stomach or duodenum was ruled out by the normal appearance of these organs in the early films and by the fact that the segment of gut had not filled until 2½ hours. The large gut was seen to be quite distinct. A fistulous communication with the gall-bladder was also considered, but again the late filling would necessitate the fistula being between the gall-bladder and lower ileum, a most unusual site, and in no picture was barium seen in the biliary tree. It was finally decided that the condition was probably one of a Meckel's diverticulum with the segment of gut bearing it fixed in an abnormally high position in the abdomen by inflammatory adhesions from the previous abscess discharging at the umbilicus.

**OPERATION**—The abdomen was opened under general anaesthesia through a long right paramedian incision and the peritoneal cavity was found to be free of any band or adhesion or other evidence of past

inflammation. This included the area deep to the umbilicus. There was no Meckel's diverticulum or band. The cause of the attacks of obstruction was, however, quite obvious. A circular hole was present in the transverse mesocolon about 1 in from the hepatic flexure and through this was herniated a loop of the terminal ileum. The margin of the hole gripped the gut quite firmly without being tight enough to cause obstruction or interference with the vascular supply, but on withdrawing the gut constriction grooves were apparent on the afferent and efferent loops. The defect was found to be circular, about 1 in across and situated close to the mesenteric border of the colon. It was closed by three interrupted silk sutures and the abdomen closed in layers.

Convalescence was uneventful and the patient has remained free from symptoms.

### SUMMARY

Reference is made to recorded cases of intestinal obstruction due to hernia of the gut through holes in the mesentery of the small and large gut, in which almost invariably diagnosis was made at laparotomy for acute intestinal obstruction of unknown aetiology.

A case is described presenting symptoms of intermittent small-gut obstruction over a period of months, but in which details of the history and radiological examination strongly suggested an incorrect diagnosis of a Meckel's diverticulum.

I am indebted to Colonel E A P Brock, late R A M C, for permission to report this case.

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## AN ENORMOUS EPITHELIOMA ADENOIDES CYSTICUM OF THE SCALP

By P GABARRÓ

PLASTIC SURGEON AT AN E M S HOSPITAL

### WITH A PATHOLOGICAL REPORT

By S L BAKER

PROFESSOR OF PATHOLOGY AT THE UNIVERSITY OF MANCHESTER

THIS tumour, a benign type of epithelioma, was described as long ago as 1842 by Ancell and since then many other descriptions have appeared. Cohn (1892) called it "multiple sarcoma", Poncet (1890), Delaye et al (1931), de Beurmann (1941), Pinkus (1922) have used the term "cylindrome", while Spiegler (1895) called it perithelioma. Ronchese (1933) thinks it most probable that the tumour originates from the sebaceous glands. Savatard (1922) describes this tumour as of the basal-cell type, originating from the surface epidermis or from the hair follicles. He uses the term "epithelioma adenoides cysticum", and this term is adopted in the present paper.

These tumours, when of such great size that they cover the head, have been referred to as "turban tumours". Savatard describes many cases in which the condition is familial, in the following case there is no familial history.

This case is similar to several described by other authors, but it appears to be the largest "turban tumour" so far recorded. It is interesting because, apart from the unique size of the tumour, it appears to be the first in which radical surgical removal has been successfully performed.

### CASE REPORT

**HISTORY**—The patient was a married woman, aged 60. Thirty-three years ago she noticed some small tumours in the region of the right eye. These increased in size and spread until the whole forehead and most of the cheeks and scalp were covered by tumours which continued to grow (*Fig 221*). During the last few months prior to operation the tumours grew more rapidly. Many also appeared on the body from time to time.

**ON EXAMINATION**—The growth consisted of a conglomeration of rounded tumours covering the following area: just over the eyebrows, descending on both cheeks in front of the ears, behind both ears, and rising

slightly to the upper part of the occipital region. Inside this area there were very numerous papillomatous outgrowths which overhung, covering both eyes, the nose, and both ears. Many tumours were pedunculated and had a smooth pink surface, generally soft. Several had ulcerations at the peduncular ends which bled easily. A great deal of secretion had accumulated over the area involved, possibly a mixture of sebaceous material, some blood, and discharge from the ulcers. Much of the hair remained. The whole had a very strong, unpleasant smell, like butyric acid, similar to the sebaceous secretion accumulated in cysts.

In the midline of the back there were about thirty smaller tumours, some ulcerated and bleeding, varying

it was decided that the best way of treating the growth would be the boldest—to remove all in one piece, mostly by blunt dissection after the edges had been freed. For a fortnight the scalp was washed daily with a diluted solution of cetavlon in saline. This was necessary to remove all accumulated secretions and concretions.

**THE OPERATION**—The operation was performed by the writer on March 25, 1943. Before starting on



FIG 221—Patient's head before operation

in size from a pea to a lemon. This midline appearance is described by Savatard as characteristic.

There were several smaller tumours spread over the abdomen but they were much more numerous along the midline (Fig 222) and on the external genitals, small tumours were scattered on both legs.

There was no pain or any other symptom which affected her general condition, except in the social aspect. On account of the size, smell, and ugliness of the tumour she remained in hiding in her home for more than ten years. She was "discovered" by the doctor when her second husband died and was sent to hospital for treatment, which she accepted reluctantly.

**THE SURGICAL PROBLEM**—The enormous size of the tumour, the quantity of blood collected in it, together with the age of the patient, presented a very serious surgical problem. Was it advisable to remove the tumour, and if so should it be done by stages or in one operation?

Anatomically the tumour was confined to the soft tissues. A radiograph of the skull did not show any lesion of the bone. The best *plan de clivage* for excision would be between the scalp and the pericranium, and presumably once one edge had been dissected up, the rest could be removed in one piece, leaving the aponeurosis covering the bone. It was clear that the hair could not be preserved. Bearing these considerations in mind,

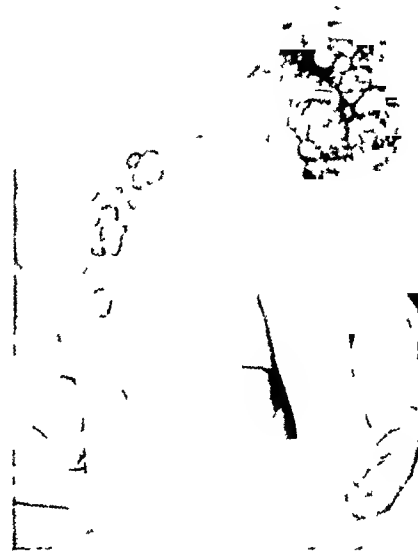


FIG 222—Back view, showing string of lumps down the midline

the scalp, two pieces of thick skin-graft, each 8 in.  $\times$  4 in., were cut from the abdomen with the Padgett dermatome.

To avoid as far as possible loss of blood, the main arteries of the scalp were tied by deep sutures placed beyond the limits of the tumour. The dissection of the tumour was commenced at the left temporal side. Provisional scalp haemostatic forceps were fixed. Even with these precautions the first incision led to a serious sudden loss of blood with a subsequent fall of pressure and apparent collapse of the patient. The blood came more from that collected in the tumour itself than from the network of small arterics. Speed was essential for success and in ten minutes the whole tumour had been



FIG 223—Tumour removed in one piece

excised. The frontal region remained covered by the aponeurosis, but the rest of the skull was left bare. As quickly as possible the grafts were fixed in position at the top of the cranium. The sides were left raw.

Because of the sudden fall of pressure, bleeding stopped. Full advantage was taken of this, all the

haemostatic forceps were removed, very few ligatures were used, and when the patient's blood-pressure recovered a bandage had already been fixed over the whole scalp applying strong pressure.

The tumour was removed in one piece. Its size was 12 in.  $\times$  6 in., weight 4 lb 2 oz (Fig 223). It is now preserved in the Museum of the Department of Pathology, University of Manchester.

PROGRESS—Although the general condition gave much anxiety, the patient was fairly well in a few days and recovered completely.

Eleven days later the dressing was removed. Little more than 50 per cent of the graft had taken. The back



FIG 224—The head after operation

and sides of the scalp remained raw showing much bare bone. Wet dressings were applied to the bone surface and a fortnight later most of it was covered by granulating tissue.

At a second operation on May 3, 1943, the granulations were shaved down and a continuous sheet of split graft was placed on the raw surface.

Seven days later examination showed the graft to be a complete failure. Two days later a split graft was cut in Gabarro's squares (1943) and placed on the raw area. Four days later the dressing was done although there was abundant pus most of the squares had taken well. A fortnight later practically all the grafts had spread and the whole area was covered by epithelium.

Two facts deserve some comment—

1. On account of the bandages several of the tumours had been under some pressure for a few days. The result was that the tumours were depleted (blood secretions? cells?) and reduced in size, they remained so afterwards. It seems likely, therefore, that pressure might be an aid in the treatment of isolated tumours and might possibly arrest growth.

2. The graft used at the second operation, which was a split graft and placed in *one piece* on the granulations covering the bone, failed completely. The same type of graft, cut in squares following the technique described by the writer (1943) and put on the same area two days after the first had failed, took very well and covered the whole area with new epithelium in less than 20 days (Fig 224). On this occasion it was shown once more that the 'island' type of graft was successful where the sheet graft failed.

So far, the other tumours, spread all over the body, have not been treated.

## PATHOLOGICAL REPORT

By Professor S. L. BAKER

REPORT ON SECTIONS OF ONE OF THE PEDUNCULATED MASSES—Epidermis and a thin layer of dermis covers the surface of the tumour tissue, which consists of spherical, ovoid, or irregular masses of basal cells. Each of the main masses is composed of a conglomeration of small cell masses of irregular shape. Most of the cell masses show no structural differentiation, in places, however, there is a branching gland-like arrangement, and the development of hair-follicle structures and small



FIG 225—Photomicrograph of section through tumour tissue showing irregular branching cell masses, some of which approach the structure of hair follicles fairly closely, also small cystic spaces ( $\times 150$ )

cystic spaces surrounded by epithelial cells give the picture (Fig 225) characteristic of epithelioma adenoides cysticum (vide Savatard, 1938).

## SUMMARY

A case of epithelioma adenoides cysticum of the scalp, apparently the largest recorded, is reported. It was completely removed and the result was successful. The distribution of the tumours and the surgical treatment are given in detail. There is a pathological report of sections and some bibliography.

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## SARCOMA OF THE METATARSAL BONES

## A BRIEF REVIEW OF THE LITERATURE, WITH ONE PERSONAL CASE

By IVOR J THOMAS

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SARCOMA of a metatarsal bone is sufficiently rare to warrant the publication of an individual case

## CASE REPORT

**HISTORY**—I P, a male aged 70 years, was admitted to the Cardiff Royal Infirmary on Nov 16, 1943, with a swelling of the right foot

In February, 1942, twenty-one months before admission, the patient was working as a labourer, when a heavy iron rail fell on to the dorsum of his right foot, which became swollen and painful. The pain and swelling, however, soon disappeared.

Three months later, while riding in a bus, the patient felt a "dead" pain in the right fore-foot. Ten months later he noticed a swelling for the first time in the region of the base of the right hallux, and the foot was now very painful.

Seven months before admission he had to take a size larger in shoes, and two months later was examined by his private doctor. When the patient was examined at the Out-patient Department of the hospital on Sept 8, 1943, the swelling had increased in size, and a piece of the shoe had been cut away to allow for it. The foot now was always painful, but the patient could manage to walk, although with a distinct limp. He was X-rayed on this date, and the radiologist, Dr Wakeman, reported "Right foot. Except for the head, the first metatarsal is almost completely absorbed. Patchy calcification in the large tumour which replaces the bone. Consistent with osteochondroma. Sarcoma may supervene on this condition" (Fig 226).



FIG 226—Radiograph of the foot, showing the tumour involving the first metatarsal

**ON ADMISSION (Nov 16, 1943)**—The patient's only complaint was of a painful swelling of his right foot. His general condition was good.

There was a diffuse swelling of the medial part of the right fore-foot, in the region of the first metatarsal (Fig 227).

The swelling was of a fairly hard consistency, with a smooth surface, an ill-defined edge, gradually tapering

away in the region of the shaft of the proximal phalanx of the hallux, and laterally in the region of the shaft of the second metatarsal. The skin over the swelling was smooth and glossy, but was not directly involved by the neoplasm. There was no evidence of metastases.

Another radiograph of the foot was taken on Nov 11 (10 weeks after the first) and the radiologist reported "Comparison with the film of Sept 8 shows increase in size of the tumour from 1½ in diameter to 2½ in



FIG 227—Photograph of the foot, showing the swelling in the region of the first metatarsal

diameter. This strongly suggests a neoplastic condition, i.e., sarcoma."

On the clinical and radiological evidence a diagnosis of sarcoma of the first metatarsal bone was made.



FIG 228—Photograph of a sagittally-cut section through the first metatarsal bone showing the neoplasm

**TREATMENT**—On Nov 25, under general anaesthesia, a below-knee amputation at the site of election was performed (I J T).

Convalescence was uneventful, and there was no undue delay in the healing of the stump. He was



transferred to a convalescent home on the twelfth day after operation, from where he was discharged on Feb 3, 1944. At this time the stump was well healed and painless, and there were no signs of metastases.

**FOLLOW-UP**—The patient was re-examined at intervals, and over 14 months after operation there was no sign of a recurrence and the general condition of the patient was excellent.

#### **PATHOLOGY**—

1 *Macroscopical Appearance* (Fig 228)—A sagittally cut section of the right foot through the first metatarsal shows a nearly circular neoplasm, approximately 3 in (7.5 cm) in diameter, which has destroyed the shaft of the

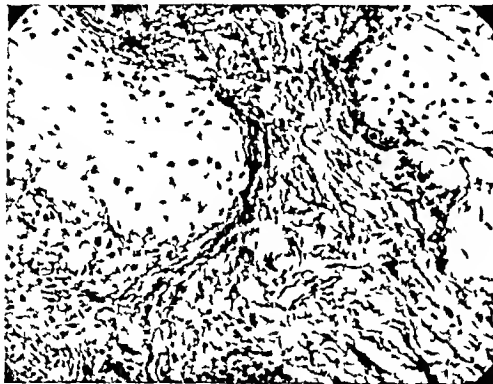


FIG 229—Microphotograph of the neoplasm, showing the typical structure of chondrosarcoma ( $\times 100$ )

bone, leaving only its base and a small part of the head, with its articular cartilage.

At no point is there any actual involvement of the skin, although it is in due apposition to the growth on its dorsal surface. The articular surfaces of both ends of the bone are intact and not invaded by the neoplasm.

The sectioned specimen reveals an osteochondrosarcoma with its centre red, fleshy, and vascular, showing areas of hæmorrhage and necrosis. In the periphery of the tumour there are islands of cartilaginous tissue of a myxomatous appearance, separated by thin connective-tissue septa. There is also a small amount of new-bone formation.

2 *Microscopical Appearance* (Fig 229)—Report by Dr J Gough: "Sections were taken from several parts of the growth and all showed the characteristic structure of chondrosarcoma. The tissue was intersected by bands of hyaline fibrous tissue in which there were no neoplastic cells. The tumour tissue proper was of varying cellularity, but even in the most cellular parts its cartilaginous nature could be recognized. There was considerable irregularity in the size and arrangement of the cells. There were areas of myxomatous degeneration and small areas showing bone formation."

## **DISCUSSION**

The literature on the subject is scanty, but a review of it shows that only comparatively rarely do malignant tumours of any kind originate in the bones of the hands and feet. This statement can easily be verified by considering the statistics of any large hospital.

In 1933 Dodd reported a case of amputation of a foot where a march fracture had been wrongly diagnosed as sarcoma of a metatarsal bone.

Watson-Jones (1943), in the recent edition of his book, mentions Dodd's paper when discussing

march fracture of the metatarsals, and writes "If sarcoma of the metatarsals was not so rare as to be almost unknown, the periosteal elevation and ossification and the absence of a history of injury might be confusing."

Mercer (1936), in his section on osteogenic sarcoma, mentions that "For some reason the short long bones appear to be immune." Illingworth and Dick (1941) consider that "Sarcoma of the smaller bones of the hands and feet is exceptional", and Kahn also pointed out that malignant tumours of the bones of the hands and feet are extremely rare.

Schreiner and Wehr (1933) surveyed a series of 10,459 cases of malignant disease over a nineteen-year period, and could find only 37 involving the foot and only 4 of these were bone sarcomas. Of 1740 bone tumours at the Johns Hopkins Hospital, Moore (1931) found 46 benign and malignant tumours of the foot, but the number of tumours occurring in the metatarsal bones was not mentioned.

The most complete paper dealing with the subject is that of Coley and Higinbotham (1939), and in a review of 1211 bone tumours at the Memorial Hospital and the Hospital for Ruptured and Crippled, New York, they found only 47 instances of involvement of the bones of the hands and feet. Twenty of these involved the bones of the hands, and 27 the bones of the foot. They note that considering there are 206 bones in the entire skeleton, 106 of which are in the hands and feet, the statistics show the disproportion of tumours in these bones.

From the American and foreign literature they were able to collect a total of 609 cases of tumours involving the bones of the hands and feet, but 205 of these were subcalcaneal exostoses. They found a remarkable sparsity of all other types of primary bone tumours of the hands and feet, but the proportionate number roughly corresponded to their own series.

The malignant tumours of the metatarsal bones in their own series totalled 10, made up as follows—

Osteogenic sarcoma	5
Giant cell tumour	2
Ewing's endothelioma	2
Angiosarcoma	1

From the literature they collected a total of 38 cases—

Osteogenic sarcoma	3
Giant-cell tumour	9
Cyst	5
Exostosis	3
Ewing's endothelioma	6
Chondroma	7
Metastatic	2

There were also 3 cases described in the literature as sarcoma of the metatarsal bones without further differentiation as to type.

In all, therefore, there were 8 proven cases of osteogenic sarcoma, 8 cases of Ewing's endothelioma, 1 case of angiosarcoma, and 3 other unclassified sarcomatous tumours.

It is difficult to obtain full accounts of all these cases, but Coley and Higinbotham have followed their 10 cases, details of which are given in Table I.

## DIAGNOSIS

The diagnosis may be one of extreme difficulty, and only after careful investigation should a sarcoma of a metatarsal bone be diagnosed

Sometimes the patient gives a history of trauma, but the true value of this in the aetiology of the condition is open to question Lichtenstein and

They note that a central chondrosarcoma begins in the interior of a bone and a peripheral one in the cartilaginous cap of an osteochondroma It is in the latter and those central ones which have clearly evolved from benign enchondroma that one finds, at least in the earlier stages of evolution of the lesion, heavy calcification or ossification of large parts of the intercellular matrix of the tumour cartilage In

Table I—COLEY AND HIGINBOTHAM'S TEN CASES

No	NAME	SEX	AGE	BONE	DIAGNOSIS	ADMITTED	TREATMENT	FOLLOW-UP	REMARKS
1	D D	M	33	R	Osteogenic	25/8/29	Amputation	11/5/32	Well
2	M R	F	34	L 2	Osteogenic	19/5/33	Amputation	16/5/35	Died, pulmon-ary metastases
3	J S	M	65	R 5	Osteogenic	8/5/31	X rays, amputation	7/11/37	Well
4	V V	M	23	R 1	Osteogenic	23/7/24	Excision, X rays	7/1/28	Final not traced further
5	L W	F	34	R 4	Osteogenic	3/3/30	X rays, radium, curettage, amputation	14/2/38	Well
6	H N	M	32	R 1	Giant-cell	22/7/26	Curettage	15/11/37	Well
7	H S	F	17	L 4	Giant-cell	30/8/37	Curettage, (re-curred) excision	13/4/38	Well
8	C F	M	33	R 3	Endothelioma	17/10/24	Excision, radium	26/9/26	Died, multiple metastases
9	E K	F	23	L 1	Endothelioma	25/10/24	Excision radium, X rays	30/4/25	Died
10	R V	M	33	R 3	Angiosarcoma	26/4/25	Amputation	5/5/25	Died, multiple metastases

Jaffe (1943), from a study of 15 chondrosarcomas of bone and a review of the cytology of benign growths, from which chondrosarcoma so often evolves, consider that trauma does not seem to be a factor in the initiation of chondrosarcoma or in malignant transformation of enchondroma and osteochondroma (In this series, however, the metatarsal bones were not affected)

Clinically, the history usually given is of pain in the affected region, followed shortly after by swelling and disability There is a hard palpable swelling which increases in size with relative rapidity

Radiographic examination shows characteristic irregular bone destruction, and possibly laying down of new bone, often with the typical 'sun-ray' appearance

Coley, Sharp, and Ellis (1931), in order to verify the clinical and radiographic findings, recommended aspiration biopsy as a valuable aid in the accurate diagnosis of the tumour

## PATHOLOGY

Lichtenstein and Jaffe (1943) have stressed the importance of differentiating chondrosarcoma from osteogenic sarcoma The former develops from fully-fledged cartilage and the latter from more primitive tissue, the bone-forming mesenchyme Some chondrosarcomas show large areas in which the intercellular matrix of the tumour cartilage has become heavily calcified or ossified, and in some osteogenic sarcomas cartilage in considerable amounts may be formed in the course of osteogenesis from the primitive mesenchyme However, chondrosarcoma never shows tumorous osteoid tissue and bone evolving from a sarcomatous stroma directly, such as one always sees somewhere in osteogenic sarcoma, no matter how much cartilage it contains

other chondrosarcomas the relevant neoplastic tissue is likely to consist, in the main, of compacted islands of cartilage with hyaline matrix, though, if the chondrosarcoma is bulky, areas in which the cartilage is softer and myxomatous and perhaps even necrotic may also be found

From a study of their material Lichtenstein and Jaffe concluded that the histological picture of a particular lesion (irrespective of its gross appearance) does not have to be crudely and obviously sarcomatous to indicate chondrosarcoma, and that it is a mistake to suppose that to make a diagnosis of chondrosarcoma on a histological basis alone is often difficult if not impossible Even in the early stages of a chondrosarcoma, they found, at least in scattered fields and if adequate material were examined, subtle but tell-tale evidence of cytological atypism of the cartilage cells which will betray the malignant character of the lesion

According to their criteria a cartilage tumour should no longer be regarded as benign if, when viable and not heavily calcified areas are examined, it shows even in scattered fields (1) Many cells with plump nuclei, (2) More than an occasional cell with two such nuclei, (3) Any giant cartilage cells with large single or multiple nuclei or with clumps of chromatin

If these criteria are observed they believe that the prevalent tendency to "underdiagnosis" of chondrosarcoma in an early stage of malignancy can be overcome

## TREATMENT

The treatment naturally depends on the type of sarcoma, the degree of malignancy, and the stage at which the condition is seen

Chondrosarcoma tends to appear at a later age than osteogenic sarcoma, runs a much slower course,

and, especially, if given radical surgical treatment, at an early stage has a much better prognosis, since the tumour has usually not metastasized at the time of the initial surgical intervention. The fibrosarcomatous type of tumour offers an even more hopeful prognosis.

As the sarcoma of the metatarsal bone is a tumour which tends to metastasize late, the best form of treatment is primary amputation. This is performed either below the knee with a 5½-in stump or through the middle of the thigh. Local excisions should not be advised.

Post-operative deep X-ray therapy should also be given in most cases, although this has not been done in the author's personal case. The only series of cases carefully followed-up is that of Coley and Higinbotham shown in the table. Five of their patients were alive and well (3 for more than 5 years), 4 died of pulmonary metastases from one to three years after admission, and 1 died following a prostatectomy nine years after amputation of the foot for osteogenic sarcoma. The other 2 were lost to follow-up, but one was undoubtedly dead, as he had pulmonary metastases six months after treatment.

From what has been said, it would appear that sarcoma of a metatarsal bone offers a more favourable prognosis than does the same condition in other bones.

### SUMMARY

A personal case of sarcoma of the first metatarsal bone is described. Treatment was by amputation

below the knee, leaving a 5½-in stump. The patient is well over 14 months later, with no sign of recurrence.

A review of the literature shows sarcoma of a metatarsal bone to be a comparatively rare condition. The 5-year cure rate is roughly 33 per cent, and it appears that sarcoma of a metatarsal bone offers a more favourable prognosis than does the same condition in other bones.

I am greatly indebted to Mr Ioan-Jones, under whose care the patient was admitted, for allowing me to operate on this case and for permission to publish this report. My thanks are also due to Dr Jethro Gough, for the histological report, to Dr Wakeman for the radiological reports, to Professor J D Duguid, and to Dr L P Thomas for the photographs.

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## A CASE OF COMMON ILIAC ANEURYSM IN A CHILD

BY NORMAN C TANNER

SENIOR SURGEON, ST JAMES'S HOSPITAL, LONDON

ANEURYSM in adults is becoming less frequent, but it has always been a very uncommon disorder in childhood, and therefore such a case with the result of radical surgery is recorded.

### CASE REPORT

**HISTORY**—The patient, a female aged 10 years, was one of six children, the last-born of whom died in early infancy. The child had enteritis, measles, and chicken-pox in early childhood, but otherwise had been well. Her parents have good health and there have been no miscarriages, stillbirths, or congenital abnormalities in the family. She could recollect having been pushed down some steps and having had two other minor accidents in play, but no severe abdominal injury had ever been sustained. She had complained of abdominal pain on and off from January, 1944.

On March 18, 1944, she was admitted to the Aber-tillery and District Hospital with a pain in the right side of the abdomen and generally feeling out of sorts, but no vomiting. On examination there she had a temperature of 100° and tenderness in the right iliac fossa, with rigidity of the lower abdominal muscles and a palpable mass. A diagnosis of acute appendicitis with probable matting of the omentum round the appendix was made and an operation performed by Mr R W Scanlon, F.R.C.S. Under anaesthesia the mass appeared to be more central in position and so a right paramedian incision was resorted to. A small quantity of free

peritoneal fluid was found, the appendix appeared normal and was not removed. The tumour was retroperitoneal, the size of an orange, and lying over the 4th and 5th lumbar vertebrae—circumscribed and rounded, with an expansile impulse which ceased on pressure of the abdominal aorta above the swelling. It was considered that the expansile pulsation was caused by the tumour lying over the bifurcation of the aorta and that the iliac arteries communicated the apparently expansile pulsation. A tentative diagnosis of retroperitoneal abscess or dermoid was made and the abdomen closed pending further investigation.

Subsequent radiography showed no erosion of the lumbar vertebrae. There was some daily temperature fluctuation between 99° and 101.5° F for three weeks, but it gradually settled to normal in the fourth week. The patient made an excellent recovery, got up and about, but the mass remained unaltered.

**ON ADMISSION**—The patient was admitted to St James's Hospital on April 19. She was an intelligent rather spare child, weighing 3 st 12 lb, of normal stature for her ten years. Clinical examination of the cardiovascular, respiratory, and nervous systems revealed no abnormality. The blood-pressure in the arms was 104/60 and in the legs 7/60. The retinal arteries were of normal appearance. Inspection of the abdomen showed a well-healed right paramedian scar and a visible swelling with its centre 3 cm below and to the right of the umbilicus. On palpation there was now no rigidity or guarding and a mass was felt extending below

# COMMON ILIAC ANEURYSM IN A CHILD

to 2 cm above the right inguinal ligament, and across to the left of the midline and above to just above the umbilicus. It was round in shape and had well-marked expansile pulsation in all directions. The femoral pulses were equal. The mass ceased to pulsate and became smaller on pressure over the aorta. A straight radiograph showed a rounded shadow over and to the right of the 4th and 5th lumbar and 1st sacral vertebrae. Blood examination showed the Kahn test negative and the count was as follows—

R B C , 5,300,000 per c mm	C I , 0.80
Hæmoglobin, 84 per cent	
W B C , 12,400 per c mm	
Differential W B C —	
Polymorphs, 50 per cent	
Eosinophils, 1	
Lymphocytes, 41	
Monocytes, 8	

Stained film. No abnormality seen. She was afebrile on admission and remained so. It was decided to give the child a few weeks' rest in bed in view of the previous pyrexia in case there was any periarterial suppuration, and to increase the collateral circulation.

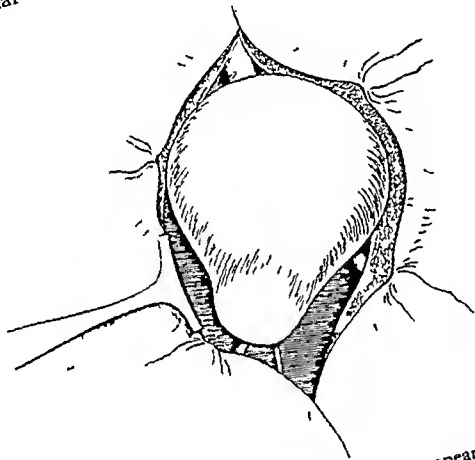


FIG 230—Reconstructed diagram of the appearance of the aneurysm at operation

On May 22 the child was re-examined and to our alarm the mass was bigger by a fresh asymmetrical bulge which gave the impression of being subcutaneous, the palpable diameters now being 9 cm by 7 cm, and it was decided to postpone the operation no longer.

AT OPERATION.—On May 23, under avertin, gas, oxygen, and ether anaesthesia in the Trendelenburg position, a right paramedian incision was re-made and multiple small aneurysmal adhesions were divided. A large mass, now aneurysmal without any doubt, was found, and to expose it adequately the incision had to be prolonged from pubis to high in the epigastrium. Above, the aorta could be felt, but the right internal and external iliac arteries were obscured by its bulk. The aneurysm had a bulge on its otherwise oval contour—the recent sudden enlargement (Fig 230). No visceral abnormality was present.

The peritoneum over the aneurysm was divided. It was some 11 cm by 7 cm in diameter and the ureter was seen coursing along its outer side. By dissection at the uppermost limit the aorta was exposed. One now gained the impression that the aorta was entering its upper part, and this was gently freed up and a silk ligature placed round it in case of accident. Downward traction on the upper pole of the aneurysm failed to show its exact origin—it was too bulky to get an adequate view. Consequently the aorta above, the left common

iliac and the right external iliac arteries were compressed after gently compressing the aneurysm. When pulsation was stopped the incision was rapidly incised, its clot extracted and the incision and aneurysm clamped with a very strong sponge forceps. The aneurysm was thereby made much smaller, about one-third its previous size, and dissection above now showed that although the aneurysmal dilatation involved the right common iliac artery at its origin, the lowest aorta and left common iliac artery appeared normal. Two firm silk ligatures were placed around the right common iliac artery at its origin from the aorta, care being taken not to obstruct the left common iliac artery although it was of necessity distorted slightly. It was now comparatively easy to ligate the external iliac artery at its exit from the aneurysm and the internal iliac artery was also tied at its separate point of exit from the sac, 2 cm from the external artery. The aneurysm was now freely reopened and found to have a very small inflow of blood. Most of the wall was excised, but the posterior wall was left in situ and obliterated completely by a series of fine interrupted silk stitches. The common iliac vein was not ligatured. A right lumbar sympathectomy was now started and the fourth lumbar ganglion was just removed when the anaesthetist suggested that signs of surgical shock were causing disquiet and so after quickly resuturing the posterior peritoneum (which had been opened almost as high as the duodenum) the abdomen was closed.

A blood transfusion had been started during the operation and was continued post-operatively. Immediately after the operation the pulse was rapid and of low tension. The right leg was blanched from the knee downwards.

On return to the ward the leg as high as the knee was kept cool by wrapping it in two layers of blanket and placing outside these four ice bags, but the rest of the body was kept warm. A transfusion of plasma later replaced the blood until the general condition gave no more cause for alarm, and heparin was added to the intravenous drip. Gentle massage was given to the leg. The foot became rather cyanosed a few hours after the operation.

PROGRESS.—On May 25 the sole and fifth toe appeared of good colour but the dorsum and first, second, third, and fourth toes were blotchy cyanosed. At this stage she had an attack of vomiting which subsided after continuous gastric aspiration by an indwelling trans-nasal oesophageal tube and restricting oral fluids for twenty-four hours.

On May 26 her vomiting had ceased. Her general condition was better and the fourth and fifth toes were pink.

On May 28 the condition shown in Fig 231 was present. On June 2 the tip of the first toe was blue with an area of doubtful viability.

On June 10 tiny necrotic patches were present at the tips of the first, second, third, and fourth toes. Now well and getting up.

On June 17 the patient was discharged with instructions to keep toes dry and powdered. The abdominal wound was soundly healed.

January, 1945. The child is now in excellent general health, the foot appears normal apart from fine scars on the tips of the first, second, and third toes, and no marked difference in colour or temperature can be discovered between the two legs.

Dr B. Barling has kindly examined the child and reports that there is now no evidence clinically, radiologically, or electrocardiographically of any congenital abnormality in the cardiovascular system, of congenital syphilis, or of recent or past rheumatism.

MICROSCOPY OF THE WALL OF THE ANEURYSM (Dr A. B. Bratton).—The histological report on the excised part of the aneurysmal wall was as follows—

"The specimen consisted of two irregularly oblong portions, the larger 1 cm long by 0.5 cm deep, of tough, brownish-grey tissue showing no definite structure

"Microscopically they are seen to be portions of arterial wall in which great fibrosis has rendered the coats not easily distinguishable. There is great hyaline fibrosis of the intima, which is in places lined with

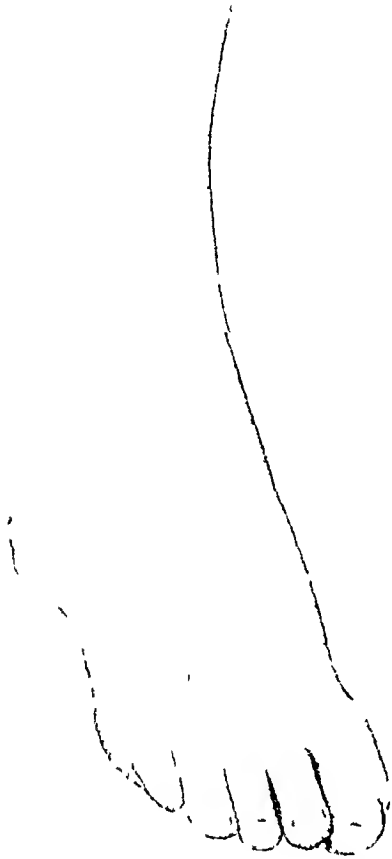


FIG 231—Appearance of foot on May 28, 1944, five days after operation

structureless adherent clot. In the smaller portion there is between the intima and media a cleft, the walls of which show chronic inflammatory infiltration, especially on the medial side.

"There is great fibrosis of the media, little elastic remaining, in one place in the larger portion it is narrowed in a tapering manner almost to nothing. There is a slight excess of vascularization in the media.

"The adventitia is fibrotic and greatly thickened. In it is an area of chronic inflammatory infiltration and a few nodules of foreign-body giant-celled granulation tissue, a giant cell in one of these includes an elongated, unstained, refractile foreign body and others show clefts.

"There is no evidence of activity of the process that produced this result. The presence of the foreign body is somewhat suggestive of a traumatic origin."

### COMMENT

Aneurysm in children is an uncommon disease and most of the recorded cases have been in the first part of the aorta, and most have ruptured spontaneously. Pilcher, in 1937, reported 4 cases of

aneurysm of the thoracic aorta and cited Calvin and Nicham's series of 44 thoracic aortic aneurysms.

Aneurysm of the abdominal aorta appears to be much rarer in childhood, though W. E. Tanner, in 1926, described a case in a girl aged 15 involving the lower end of the abdominal aorta, which ruptured with fatal effects while the child was awaiting operation as a probable appendix with a palpable mass.

I can find no reference to iliac aneurysm in childhood, but in 1926 N. C. Lake described a sacular aneurysm of the common femoral artery which he successfully excised in a child aged 10. Bronson and Sutherland recall two cases of ruptured aortic aneurysm in childhood described in 1834 and 1857 by Miquel and Armitage respectively.

The aetiology of the condition is often difficult to elucidate with certainty. Bronson and Sutherland in 1918 suggested the following classification of aneurysm in childhood: (1) Arteriosclerotic, (2) Traumatic, (3) Embolic or septic, (4) False, due to erosion from without, (5) Congenital anomalies.

Of the 48 thoracic aneurysms recapitulated by Pilcher, 24 were associated with endocarditis or rheumatic fever, 2 with syphilis, 5 were the result of external erosion by suppurating or caseous lymph-nodes, 5 were associated with congenital anomalies of the aorta, and 2 were doubtfully the result of trauma.

W. E. Tanner's case of abdominal aneurysm mentioned above occurred in the third week of scarlet fever complicated by nephritis and albuminuria and was a mycotic aneurysm.

N. C. Lake's case of femoral aneurysm had been preceded eighteen months previously by a pyrexial attack diagnosed as endocarditis, and the child had congenital heart disease. Lake considered it to be a mycotic embolic aneurysm.

In the case I have recorded the causation is uncertain. Trauma is highly unlikely in such a deep-seated vessel with so trivial a history. There is no evidence of degenerative vascular disease, syphilis, or rheumatism. Endocarditis or mycotic embolism can reasonably be excluded and apart from the preceding pyrexia which may have been due to the formation of clots in the aneurysm or peri-arterial suppuration there is no evidence in their favour. No local congenital abnormality was demonstrable at the operation. One is left with the possibilities of—

1. Erosion or infection of the arterial wall from without resulting from an iliac lymphadenitis (but there is no definite evidence of this or of an infective lesion of the area drained by this gland).

2. A possible congenital defect of the media cannot be excluded (but in the absence of other aneurysms it seems unlikely).

3. Trauma (of which there is only the most trivial history, but which is to some extent supported by the histological findings).

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## A LARGE TESTICULAR TUMOUR

BY H J NIGHTINGALE, SOUTHAMPTON

IN view of the fact that malignant disease of the testis rarely leads to a large tumour, the following case would seem to be worth putting on record

polygonal cells with a densely staining round nucleus Mitotic figures are not seen and thestroma is very scanty This is no doubt a type of embryonal carcinoma of the

## CASE REPORT

The patient was a man of 69, without friends or relations and not very intelligent, so that it was difficult to get a history from him He had a



FIG 232 —Photograph showing the enormous scrotum

scrotal swelling which had probably been present for at least 2 years, because for the last 12 months he had been in a Public Assistance Institution

His condition when first seen is shown in the photograph (Fig 233), the scrotum reaching to the knees Walking was impossible, and he was in great discomfort, so that operation was decided on

At operation, the only difficulty was found to be in the network of large veins in the skin of the scrotum, many of which were the size of a lead pencil The growth was infiltrating the skin in the lower part, but the upper part of the tunica vaginalis was patent and contained 3½ pints of fluid

After satisfactory progress for 4 days, he suddenly collapsed and died A post-mortem examination was held and no glands or secondaries were present

THE SPECIMEN—I am indebted to Dr Gleave, Pathologist to the Royal South Hants and Southampton Hospital for his report "This huge tumour (weight 11 lb 4 oz) (Fig 233) shows on section soft brain-like new growth with a large amount of hæmorrhage and necrosis which obscures the histology (Fig 234) The tumour is made up of rounded or

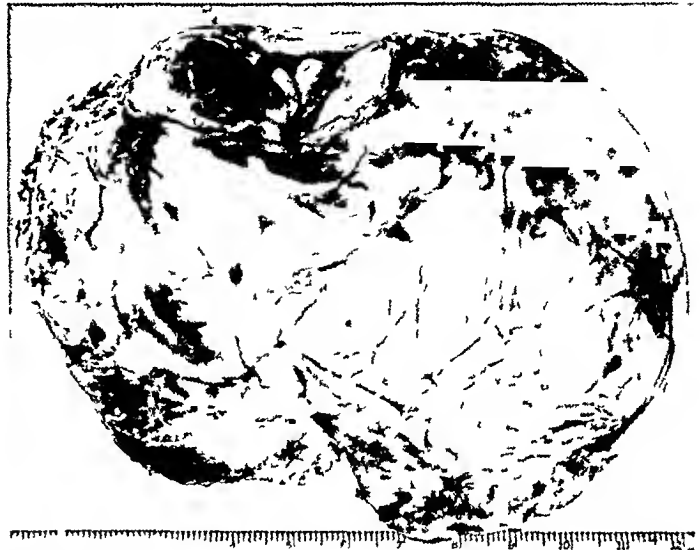


FIG 233 —The tumour



FIG 234 —Section through the tumour, showing hæmorrhage and necrosis

testis, though the typical glycogen-containing cells are not seen"

The specimen is now in the Museum of the Royal College of Surgeons

## A FIBROLIPOMA OF THE CHEEK

BY CHARLES NOON, NORWICH

A FIBROLIPOMA of the cheek which can be protruded through the mouth by the patient at will is rare, and would seem worth reporting

## CASE REPORT

I saw this patient in consultation with Dr Healey in December, 1942. The patient had been an inmate of a mental hospital for many years. A tumour began to

could cause the tumour to prolapse through the mouth and with equal ease and a slight sucking effort again retract it into the cheek. The position as it protrudes through the mouth is shown in Fig 236. As the tumour caused no inconvenience, the patient was most reluctant to consider any operation for its removal. No operation was therefore done during life. The tumour was removed post mortem. Fig 237 shows the fibrolipoma after removal.

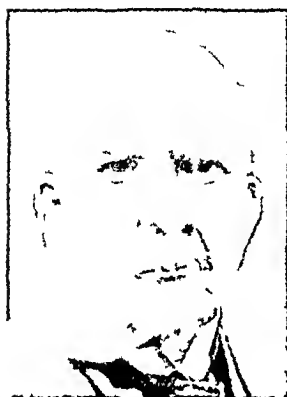


FIG 235 —Fibrolipoma of cheek



FIG 236 —Fibrolipoma protruding through the mouth

develop in the right cheek about twelve years ago, it gradually increased in size until it extended downwards over the lower jaw and hung down from the cheek. Its size and position is well shown in the photograph (Fig 235). It was well defined, soft in consistency, had definite margins, and was freely moveable. It gave the patient no inconvenience. Without the slightest difficulty he



FIG 237 —Photograph of the fibrolipoma after removal

**HISTOLOGICAL REPORT**—Section of the tumour shows adipose tissue with a large admixture of fibrous tissue. No capsule formation is present in the material examined. There is a thin covering of squamous epithelium on one surface, with an underlying chronic inflammatory reaction. The epithelial covering is replaced in part by granulation tissue. The histological features are those of a fibrolipoma.

## REVIEWS AND NOTICES OF BOOKS

**An Index of Differential Diagnosis of Main Symptoms** By various writers. Edited by HERBERT FRENCH, CVO, CBE, MA, MD Oxon, FRCP, Consulting Physician, Guy's Hospital, late Physician, H.M. Household, assisted by ARTHUR H. DOUTHWAITE, MD, FRCP, Physician, Guy's Hospital, Honorary Physician, All Saints' Hospital for Genito-urinary Diseases. Sixth edition. 9½ x 6½ in. Pp 1128 + viii, with 798 illustrations, of which 231 are coloured. 1945. Bristol: John Wright & Sons Ltd. 84s.

THE new sixth edition of Herbert French's great work has been thoroughly revised and brought up to date. It is a large volume, consisting of over 1100 pages, profusely illustrated and beautifully printed on good paper, which is a triumph for medical publication in war-time.

Dr French has taken Dr Douthwaite as his collaborator in this edition, and one is interested to read that Dr Douthwaite will be responsible for future editions. This book has become the mainstay, not only of general practitioners, physicians, and surgeons the world over, but has become a book of reference for the whole medical

profession who want to look up any special disease or condition.

The coloured illustrations, which are numerous, have always been a feature of this book and they are a great help in the elucidation of the text.

We fail to see how a better book could possibly have been written on the Differential Diagnosis of Main Symptoms. The Index is most comprehensive and occupies no less than 183 pages. This book will continue to take its place among the really important medical books.

**Plaster of Paris Technic** By EDWIN O. GECKELER, MD, Associate Professor of Orthopaedic Surgery, and Chief of the Fracture Service, Hahnemann Medical College and Hospital, Philadelphia. 9 x 6 in. Pp 220 + x, with 208 illustrations. 1944. Baltimore: The Williams & Wilkins Co (London: Baillière, Tindall & Cox). 16s. 6d. net.

THIS book should find a useful place in the libraries of the orthopaedic and fracture departments of hospitals both large and small.



# REVIEWS AND NOTICES OF BOOKS

The early chapters provide adequate and well set-out information on the making of plaster bandages, the technique of bandaging, and the instruments and appliances generally used in the plaster theatre. These chapters would be of especial benefit to the Orthopaedic Sister or Senior Nurse. The need for padding and bivalving post-operative plaster casts cannot be too strongly emphasized, but there is much repetition of this and other statements in the text and legends of the later chapters.

Although in his preface the author explains that "orthopaedic technic and reduction of fracture have been intentionally avoided", it is difficult not to criticize the rationale of some types of plasters illustrated. An above-spica for an acromioclavicular dislocation, an above-elbow plaster for a Colles's fracture, and a plaster extending from below the elbow to the terminal phalanx in the treatment of a fractured metacarpal—all these are examples of over-elaborate immobilization of a limb.

The book is well produced and the illustrations clearly show the high standard of plaster technique achieved by the author in his own clinics.

**Surgery of the Hand** By STERLING BUNNELL, M.D.  
10 x 7 in Pp 734 + xviii, with 597 illustrations  
1945 Philadelphia and London J B Lippincott  
Co 72s net

THIS large monograph is comprehensive and lavishly and beautifully illustrated. At no time in the history of man has the human hand been subjected to such a variety of trauma, for in this mechanical age the various traumatic lesions to which the hand is liable are legion and the second world war has greatly increased the number of mutilated hands which require reconstructive and plastic surgery.

Malformation, injury, and infection swell the ever-coming stream of crippled hands needing repair. The author has tackled all these main problems in a thorough and practical manner and has demonstrated his technique of dealing with the restoration of cut tendons in an excellent fashion.

The damaged hand is often a complex problem as far as treatment is concerned, for it necessitates the correlation of various specialties—orthopaedic, plastic, and neurological surgery. No doubt this will soon be covered by the industrial surgeon of the future. Dr Bunnell is to be congratulated on having presented the profession with such a useful book.

**A Text-book of Surgical Pathology** By CHARLES F W ILLINGWORTH, M.D., Ch M., F.R.C.S. (Ed.), Regius Professor of Surgery, University of Glasgow, and BRUCE M. DICK, M.B., F.R.C.S. (Ed.), Surgeon for Diseases of the Chest, E.M.S., West of Scotland.  
Fifth edition 9½ x 6 in Pp 728 + viii, with 306 illustrations 1945 London J & A Churchill Ltd 42s

THIS text-book of surgical pathology was born to popularity amongst students and practitioners alike, for it covered the subject in a concise and masterly fashion. Small wonder then that the fifth edition appears a little over ten years after the first edition, and the fourth edition was reprinted.

This new edition has been brought thoroughly up to date and new illustrations have been added. A number of new subjects have been added, chief of which are the crush syndrome, sarcoidosis of Boeck, solitary plasmacytoma of bone, adenolymphoma of the salivary glands, argentaffine tumours of the intestine, and interstitial-cell tumour of the testis.

An excellent text-book.

**Surgical Disorders of the Chest** Diagnosis and Treatment By J. K. DONALDSON, B.S., M.D., F.A.C.S., Major, M.C., A.V.S., Associate Professor of Surgery and in Charge of Thoracic Surgery, University of Arkansas School of Medicine, etc.  
9 x 5½ in Pp 364, with 127 illustrations 1945 London Henry Kimpton 33s net

COMPREHENSIVE monographs on thoracic surgery are comparative rarities, and it is in consequence gratifying that this work of Major Donaldson's is now available. The book is written primarily for the general practitioner and general surgeon, so that there can be little criticism from the specialist in this branch who might wish to join issue on a good many points of detail. The only real objection that can be offered to this otherwise admirable book is the fact that the main principles of thoracic surgery tend to become lost in a mass of detail which might in part have been omitted.

Some chapters read very well and clarify difficult subjects, and the section on lung abscess, for example, is most satisfactory. Injuries, oesophageal lesions, and carcinoma of the lung receive careful consideration, but the treatment of empyema—a vitally important matter—is dismissed briefly without much indication as to the control of healing or, indeed, as to the whole course of action.

The number of suggested modifications for thoracoplasty suggest that the standard paravertebral operation with apical mobilization as routinely practised in this country has not found full acceptance in the author's hands and the same applies to pulmonary excision where dissection of the individual hilar elements has now almost completely supplanted mass ligature or snare technique. The advisability of performing lobectomy in a free or adherent pleural cavity is not made quite clear, nor are the complications that follow this operation given full consideration, but these are minor comments against the background of well-analysed material. No mention is made of physiotherapy and the specialized breathing exercises which have proved so valuable in all branches of chest work.

The illustrations are satisfactory, consisting of diagrams which amplify technical descriptions and photographs and radiographs relevant to the text. A short bibliography is given at the end of each chapter, but this cannot be regarded as comprehensive. For the general reader interested in many of the subjects discussed, this work will prove of considerable value and affords a suitable contribution to the present state of our knowledge.

**The Art of Anaesthesia** By PALUEL J. FLAGG, M.D.,  
New York Seventh edition 9 x 6 in Pp 519 +  
xxx, with 163 illustrations 1945 Philadelphia and  
London J B Lippincott Co 36s net

FIRST published in 1916, this famous manual has now reached its seventh edition and contains an interesting account of most of the many advances in anaesthesia and analgesia which have occurred in the last three decades.

Dr Flagg has written this text-book rather as an expression of his personal experience in anaesthesia than as a compilation of contemporary American theory and practice of this specialty. And herein lies the chief attraction of the text, for the author has definite opinions of his own and discusses debatable points with fervour and an ability which verges on the histrionic. His able pen has a rare gift of description, and he uses words seldom seen by English readers, such as the verbs 'to junk' and 'to revamp', which, however, fit the text and make this book eminently readable.

With regard to ether, the author declares that "A personal experience of more than thirty years, with ether as an anaesthetic, has left the author cold to the claims of other agents suggested as basic routines." And later

"We who are familiar with the use of ether, and conscious of the place which it occupies in the art of anaesthesia, find it difficult to explain the resistance which persists against its universal employment as a basic routine. In spite of the passing popularity of ethylene, the present popularity of cyclopropane, the place which pentothal sodium occupies in selected procedures, ether remains the backbone of general anaesthesia. It carries the burden of relaxation and reflex control. Like an old uncle who has paid for a college education and establishment in practice, but whose manners seem out of date, this benefactor is kept in the background. It is not permitted to appear in the glamorous light of the newcomers. We prefer to be silent, to maintain surreptitious relations with it. What anaesthetic agent, we may well ask, has been treated with the lack of consideration, the gross carelessness accorded ether?"

Although few English anaesthetists share this fervid antagonism for ether, we feel that most will agree that the author has written the best chapter on ether anaesthesia extant.

As regards chloroform, although the author does not go so far as the edict of the Committee on Anaesthesia of the American Medical Association, which states "The use of chloroform as the anaesthetic for major operations is no longer justifiable", yet in his reiteration at the end of Chapter VI he says "Chloroform, while ideal in efficiency, is a dangerous poison. In the light of present-day pathology, chloroform should cease to be used as an anaesthetic in obstetrics."

Surgeons will be interested in an admirably lucid description of refrigeration analgesia.

There is an interesting chapter on the history of anaesthesia, with excellent illustrations portraying Homer, Du Bartas, William Shakespeare, and Dr Crawford Long.

Widely read by anaesthetists in the English-speaking countries, this privilege is now extended to Latin America, Dr Flagg having published a Spanish version of the present edition "as a gesture of goodwill and in token of a sincere and friendly effort at inter-American medical collaboration."

## BOOK NOTICES

*[The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest for our readers.]*

**Symposium on Fractures and Dislocations.** Reprinted by the United States Office of War Information from the *Surgical Clinics of North America* (Chicago Number) for February, 1945, with the permission of the publishers, the W. B. Saunders Company, Philadelphia and London. 9 x 6 in. Pp. 209 + vi, with 139 illustrations.

**Symposium on Neuropsychiatric Diseases.** Reprinted by the United States Office of War Information from the *Surgical Clinics of North America* (Chicago Number) for January, 1945, with the permission of the publishers, the W. B. Saunders Company, Philadelphia and London. 9 x 6 in. Pp. 268 + vi, with 44 illustrations.

**The Medical Annual, 1945.** A Year Book of Treatment and Practitioner's Index (Sixty-third Year). Edited by Sir HENRY TIDY, KBE, MA, MD (Oxon), FRCP, and A. RENDLE SHORT, MD, BS, BSc, FRCS. 8½ x 5½ in. Pp. 410 + ix, with 47 plates and 61 illustrations in text. 1945. Bristol: John Wright & Sons Ltd. 25s net.

**The Principles and Practice of Rectal Surgery.** By WILLIAM B. GABRIEL, MS (Lond), FRCS (Eng), Surgeon to St Mark's Hospital for Cancer, Fistula, and other Diseases of the Rectum, Surgeon to the Royal Northern Hospital. Third edition. 9½ x 6 in. Pp. 432 + ix, with 11 coloured plates and 237 illustrations, some in colour. 1945. London: H. K. Lewis & Co. Ltd. 45s net.

**Extensile Exposure applied to Limb Surgery.** By ARNOLD K. HENRY, MB (Dubl), MCh (Hon., Cairo), FRCSI, Emeritus Professor of Clinical Surgery in the University of Egypt. 9½ x 6½ in. Pp. 180 + viii, with 127 illustrations. 1945. Edinburgh: E. & S. Livingstone. 30s net.

**Technique in Trauma.** Planned Timing in the Treatment of Wounds including Burns. From the Montreal General Hospital and McGill University, by FRASER B. GURD, MD, CM, and F. DOUGLAS ACKMAN, MD, CM, and collaborators. 10 x 7 in. Pp. 68 + vii, with 17 illustrations and 3 coloured plates. 1945. London: William Heinemann (Medical Books) Ltd. 15s net.

**Duodenal and Jejunal Peptic Ulcer.** By RUDOLF NISSEN, MD, Attending Surgeon, Jewish Hospital of Brooklyn, formerly Professor of Surgery and Head of Department of Surgery, University of Istanbul, and Associate Professor of Surgery, University of Berlin. With a Foreword by Professor OWEN H. WANGENSTEIN. 8½ x 5½ in. Pp. 143, with 123 illustrations. 1945. William Heinemann (Medical Books) Ltd. 21s net.

**Tratamiento Pre y Postoperatorio.** By F. DOMENECH-ALSINA, En. Associate Professor of Surgical Pathology of the Faculty of Medicine of Barcelona, and J. PI-FIGUERAS, Surgeon, Hospital of Santa Cruz and San Pablo, Barcelona. 9½ x 6½ in. Pp. 519 + xvi, with 75 illustrations. 1945. Barcelona: Salvat Editores, SA. Price not stated.

## THE SURGERY OF THE THYMUS GLAND\*

BY GEOFFREY KEYNES, LONDON

THE thymus gland seems to have been unknown to Hippocrates and Aristotle, and was first mentioned by Rufus the Ephesian in his enumeration of the discoveries in anatomy made at the School of Alexandria under the Ptolomies. It was Galen who first assigned to the thymus its supposed mechanical function of supporting the vena cava and its tributaries, and of protecting it from contact with the sternum. This belief held the field for many centuries, being repeated in the sixteenth century by Vesalius and his successors. In the seventeenth century the structure and anatomy of the thymus were to some extent elucidated, and Glisson first suggested that its activities might be in some way connected with the growth of the fœtus. This was repeated by Sir Astley Cooper in his monograph on the thymus in 1832, and he was the forerunner of a host of investigators who, in more recent times, have endeavoured without success to demonstrate some active principle or hormone in the thymus related to growth. It was again Sir Astley Cooper who drew attention to the fact that the thymus often became enlarged in association with what we now call toxic goitre, but again this clue failed to lead to any proof that the thymus had a definite function in relation to other endocrine organs such as the thyroid. It seems, therefore, that if the thymus gland is indeed a member of the endocrine orchestra, its notes are so muffled that no one, even of the most able investigators, has been able to distinguish them. Along with this empty record of achievement in elucidating the function of the thymus, we may note an almost equal absence of surgical interest. To illustrate this there is the fact that in the whole range of the *British Journal of Surgery* from its beginning in 1913 to the present time not a single contribution has been made on the surgery of the thymus, although this journal covers the most progressive period in the long history of surgical science. It might appear, therefore, that the surgery of this organ is a somewhat barren subject, but, in fact, there is now something of interest to communicate in an account of a contribution which surgery has been able to make during the last four years towards an understanding of the pathology, if not of the physiology, of the thymus gland. It is a good example of what Lord Moynihan used to call "the

pathology of the living", when he wished to emphasize the importance of surgery in advancing our knowledge of disease in the human body.

### EMBRYOLOGY

It is obvious that the embryology of any ductless gland may have an important bearing on its ultimate function, and it is therefore desirable to know with accuracy the origin of the various constituents of the thymus. Many studies of this have been made, but the most satisfying and convincing account was that published by E. H. Norris in 1938. This investigator states that the thymus is derived from



FIG 238—The thymus in the human fœtus

the third branchial complex, that is, from both the endodermal pouch and the corresponding ectodermal sinus in the embryo. He finds that the third cervical sinus is the primordium of the primitive thymic cortex, and the source of the Hassall's corpuscles, which are the most conspicuous epithelial constituent of the fully formed gland. The epithelium of the endodermal pouch gives rise to the syncytial cytotreticulum of the gland, the cells of which are much less conspicuous than the Hassall's corpuscles in the normal gland. The bulk of the gland consists

\* A Hunterian Lecture delivered at the Royal College of Surgeons, June 13, 1945  
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of the thymic lymphocytes. These are of mesenchymal origin, and secondarily invade the gland after it has been entered by blood-vessels and connective-tissue cells. Lastly, the fibrous reticulum or framework is not derived from the epithelial elements, but from the connective-tissue cells in the adventitia of blood-vessels and in the capsule. Norris does not find that any part of the thymus comes from the fourth cervical sinus of the embryo, though other observers, notably J. R. Gilmour (1937), believe that a variable portion is derived from this source, this portion sometimes being situated in the neck in relation to the thyroid gland.



FIG 239—Stained section through the human thymus

When the human foetus is born the thymus is a relatively large structure which seems to occupy a considerable proportion of the upper thorax. It is shaped more or less as in Fig 238. As it is composed of a number of separate lobules, a section through its mass, when suitably stained, presents the appearance seen in Fig 239.

### COMPARATIVE ANATOMY

It is impossible to believe that this large and complicated structure possesses no function in the animal economy. Its presence is not peculiar to man, and I have the authority of Professor F. J. Cole, Emeritus Professor of Comparative Anatomy at Reading University, for the statement that a thymus is found in all chordate animals. That is to say, it is represented in whales, elephants, mice, and all other mammals, in birds, in reptiles, and in all true fishes. It is even said to have been identified in amphioxus, the most primitive chordate of all. In one fish the developing thymus has ducts connecting it with the pharynx, presumably persistence of the endodermal pouch already mentioned, but these disappear during development. In all fully developed animals it is a ductless gland. It is usually larger in young animals than in old, but it certainly does not disappear in adult human beings, as has often been believed. This will be referred to again later.

### SURGERY OF THE THYMUS

The paucity of surgical references to the thymus in the literature of this country has already been mentioned. It has, nevertheless, attracted the attention of surgeons in other countries, particularly in France.

#### THYMIC ASTHMA

There is a well-known condition sometimes seen in young children known as 'thymic asthma', in which there is a recurrent difficulty in breathing associated with stridor and cyanosis. Death sometimes ensues. This has been supposed to be due to the pressure in the thorax of an abnormally large thymus, and attempts have therefore been made to relieve the supposed obstruction to respiration by removing the thymus. A French surgeon, M. Victor Veau (1924), reporting to the Sixth Congress of the International Surgical Society in 1923, stated that three operations had been tried: (1) Exothymopexy, or fixation of the gland in the substernal space; (2) Resection of the manubrium sterni to relieve pressure; (3) Thymectomy. M. Veau claimed a considerable measure of success for the operation of thymectomy, which was performed through the neck. First, an incision was made above the suprasternal notch (Fig 240). Secondly,

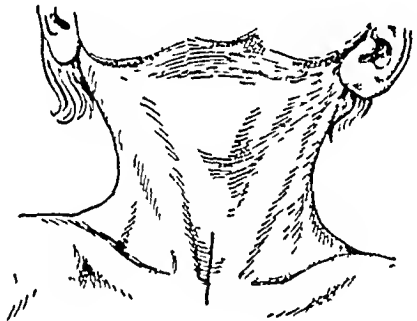


FIG 240—Thymectomy, first stage the incision (After Veau)

the soft tissues were dissected down to the thymus (Fig 241). Thirdly, the capsule of the gland was seized, and part of the gland dragged up through the opening (Fig 242). It was always a partial resection, since the lower part of the gland could not be reached. None of the children operated on had died on the operating table, but 30 per cent of them were dead from various causes, such as infections or bronchopneumonia, within a month of the operation. It was claimed, however, that in four-fifths of the operated children the attacks of suffocation ceased, and stridor was less. In 1910 M. Veau had proclaimed *c'était l'âge d'or de la chirurgie thymique*, but this golden age was short-lived. Medical opinion has fluctuated as to whether the thymus gland is really the cause of thymic asthma, and it is no longer generally believed that the thymus is the cause of death in the so-called "status lymphaticus".\* But apart from this there was another good reason why

\* This much debated question was settled in the negative by Young and Turnbull in 1931, working for the Status Lymphaticus Investigation Committee.

surgery for this condition has faded out and has not been heard of for many years

An enlarged thymus gland can be demonstrated in infants by X-ray photographs because of its relatively large size, as is seen in *Fig 243, A*. But,

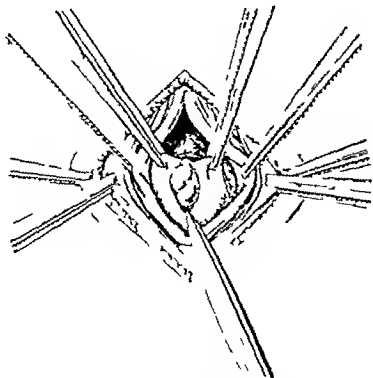


FIG 241—Thymectomy, second stage dissection of the soft tissues (*After Veau*)

consisting largely of lymphoid cells, it can be made to disappear rapidly under X-ray irradiation. *Fig 243, B* shows the effect of irradiation on the thymus seen in *Fig 243, A* (Dr Ralph Phillips)—a sufficient demonstration of why surgical treatment has ceased to be practised

None of these would have been amenable to surgical removal, though the 14 tumours called lymphosarcoma and Hodgkin's disease could be temporarily improved by X-ray therapy. The removal of thymic tumours has, in fact, seldom been attempted, and most of those that have been removed were in patients who had myasthenia gravis associated with the

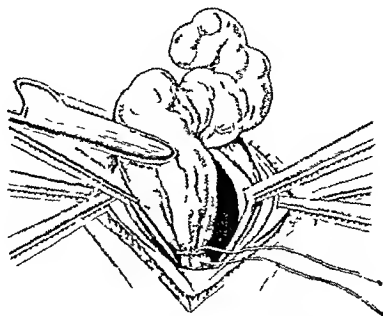


FIG 242—Thymectomy, third stage exteriorization and ligature of the gland (*After Veau*)

growth. It seems that of the five kinds of thymic tumour just mentioned, the epithelial tumour is the only one that is ever found coexisting with myasthenia gravis, and furthermore, when the epithelial tumour does occur, the association with myasthenia is almost invariable.



A



B

FIG 243—Radiographs showing the effect of irradiation of an enlarged thymus. A, Before irradiation, B, After irradiation

### THYMIC TUMOURS

The other possible application of surgery to the thymus was in the removal of tumours arising from the gland. Thymic tumours are, however, uncommon. A report on this point published in 1932 by Symmers (1932) records that among 17,000 post-mortem examinations performed at the Bellevue Hospital, New York, 24 thymic tumours were found. These were constituted as follows—

Lymphosarcoma	9
Perithelioma	8
Hodgkin's disease	5
Spindle-celled sarcoma	1
Epithelioma	1

The first recorded operation for benign thymic tumour with myasthenia was done by Blalock, of Baltimore, in 1936. This was successful, the patient being well four years later. Campbell reported two more such operations in 1941, one patient surviving with improvement. Two similar attempts which had been made in Germany by Sauerbruch, reported by Adler (1937) and Obiditsh (1937), resulted only in the death of the patients.

The mention of the epithelial tumours has thus introduced the disease known as myasthenia gravis, and at this point a digression must be made into the realms of medicine and physiology.

### MYASTHENIA GRAVIS

Myasthenia gravis is reputed a rare disease, and many practitioners pass through the practice of a lifetime without ever having seen an example of it.

It is, however, probably not really so uncommon as is usually supposed. It is one of those chronic complaints of which little has been heard because treatment has been unsatisfactory, so that patients have been shelved as ones who could not be helped beyond a certain point. Patients of this type seem to accept their fate, and tend to be forgotten. Once some new and more effective treatment becomes established those forgotten ones that have survived begin to emerge from their hiding places, and a supposedly rare disease is found not to be so rare after all. This is already happening in relation to myasthenia gravis with the new hope afforded by the surgical treatment that has recently been practised.

Myasthenia gravis in its severer forms is a truly terrible disease. The extreme muscular weakness and a sense of hopelessness pervade the patient's mentality, and this makes worse the already melancholy aspect so often resulting from the fallen

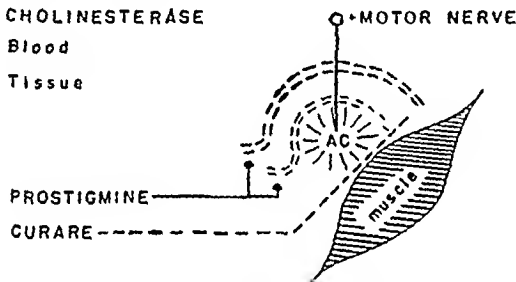


FIG 244—Diagrammatic representation of action of acetylcholine (After McEachern)

eyelids, the hanging jaw, the snarling expression when the patient tries to smile, and enfeebled limbs. In addition, the eyes move unequally, or even become completely immobile, and speech is reduced to a few imperfectly articulated words. Many patients cannot raise their food to their mouths, and when it is put there cannot chew it. Fluids are regurgitated through the nose, coughing is feeble and ineffective, and breathing is shallow. No wonder that the ultimate fate of these unfortunate people is so often a terminal infection of the lungs.

The clinical picture of myasthenia gravis presents endless variety, and is fascinating to study, but this is not a medical communication and it must not enter into too much clinical detail. Mention must be made, however, of the immense lightening of the burden that most of these patients have experienced since the introduction by Remen in 1932 of the drug prostigmine, its use in this country being due largely to the work of Dr Margaret Walker (1934), of the L.C.C. Medical Service. Through its agency no patients have been cured, but the lives of many have been prolonged for years, and nearly all have been enabled to live at a higher level of activity for the time that they were spared. It is, of course, only with the help of prostigmine that any operation on these patients can be fairly safely performed.

This leads to a brief review of the theory of causation of myasthenia gravis, and Fig 244, after McEachern (1943), presents the idea in a simple diagrammatic form. It is believed that the substance called acetylcholine is produced in the neighbourhood of the junction between the motor nerve-endings and the muscle-fibre. When the nerve is stimulated a minute quantity of acetylcholine is exploded, and this chemical change somehow activates the muscle. Limitation of its action is determined by the presence in both blood and tissues of another substance, cholinesterase, an enzyme which destroys excess of acetylcholine. The balance of these reactions results in normal action of voluntary muscle. The poison curare, which produces paralysis of voluntary muscles, is believed to act by interfering with the response of the muscle-fibre to the chemical stimulus. The state of the myasthenic patient is very much like curare poisoning, and the facts are best fitted by the supposition that the circulation of such an individual contains a substance which tends to inhibit the production or the action of acetylcholine. It has, in fact, recently been demonstrated by Wilson and Stoner (1944) at Sheffield that the serum of myasthenic patients does contain a substance which can be proved in the laboratory to interfere with transmission of an impulse in an ordinary muscle-nerve preparation. Another experiment done in Australia (Trethewie and Wright, 1944) has shown that myasthenic serum interferes with the production of acetylcholine by nerve-cells. In the myasthenic patient, therefore, muscular activity is enfeebled in all parts of the body, though why different muscles and muscle-groups should be affected so unequally and erratically as they are has not been explained. It appears, however, that myasthenia is not a disease of the nervous system, nor of the muscular system, but is a biochemical abnormality likely to depend on one of the endocrine organs of the body, since the effect is general, and its agent must be carried by the circulation of the blood. The action of prostigmine in alleviating the myasthenia is believed to be by inactivation of cholinesterase, so that acetylcholine can act in greater concentration on the muscle. It would not have been suggested that the thymus gland was to be incriminated as the source of the poison producing the disease, had it not been noticed many years ago that occasionally tumours of the thymus were associated with a myasthenic state, and it was presumably on this basis that, as long ago as 1912, Sauerbruch (Schumacher and Roth, 1913) attempted to remove the thymus gland from a myasthenic patient. The operation was done through the neck, and cannot have been complete, though the patient's condition was improved. The experiment was repeated by Haberer in 1917 and again the patient was improved, but nothing more was heard of the operation until 1941, when Blalock, of Baltimore, who, as mentioned, had already successfully removed a thymic tumour from a myasthenic patient, reported that he had tried the effect of deliberate removal of the thymus for myasthenia although there was no demonstrable tumour. But, unlike Sauerbruch, he realized that a total thymectomy could only be done by opening the mediastinum, so as to give a complete exposure

of the gland This was a bold, but logical, step, and all honour is due to Blalock for having had the courage to do it Having done the operation six times in 1941, beginning in July, he published a short report at the end of the same year, and the results he obtained were favourable enough for him to recommend a continued trial of the operation In August, 1944, he reported on a series of twenty thymectomies, and his results continued to justify the procedure Meanwhile, in February, 1942, Dr Carmichael and Dr James Carson, working at the National Hospital for Nervous Diseases, Queen Square, invited me to do the operation on a myasthenic patient under their care, since she was

sensible, as recommended by Blalock, to approach through a midline incision, splitting the sternum down to the third or fourth interspace This has been found to give direct access and complete exposure of the mediastinum, so that there was no need to complicate the operation by any transpleural line of approach The details of the operation are as follows —

1 The subcutaneous layers are infiltrated with adrenaline 1-500,000 in normal saline transversely

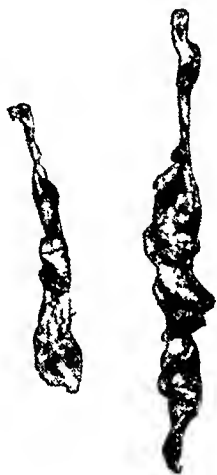


FIG 245 —The first thymus gland removed

obviously going to die very soon if the disease was left to take its course This patient, a woman of 31, was bedridden and helpless in spite of large doses of prostigmine, and was clearly a very bad surgical risk, the more so as she had to be put in the hands of surgeons and nurses who were totally inexperienced in the management of myasthenic patients

The thymus gland\* (Fig 245) was removed, and the patient, after a very rough passage, came safely through, and has, since that time, been able, with ups and downs, to lead a relatively active life, that is for over three and a half years For a year after the operation she was, indeed, able to work for ten hours a day on the land Beginning in February, 1942, I have performed the operation fifty-one times Having had the good fortune to be associated for many years with Sir Thomas Dunhill and his work, I was accustomed to exploration of the mediastinum in search of thyroid and parathyroid tumours, although I had never knowingly dissected the thymus gland Knowledge of the thymus was, indeed, everywhere somewhat sketchy, and the very text-books of anatomy do not give a great deal of precise information

### THE OPERATION OF THYMECTOMY

The thymus being a bilobed structure lying centrally in the anterior mediastinum, it seemed

\* The specimen is in the St Bartholomew's Hospital College Museum

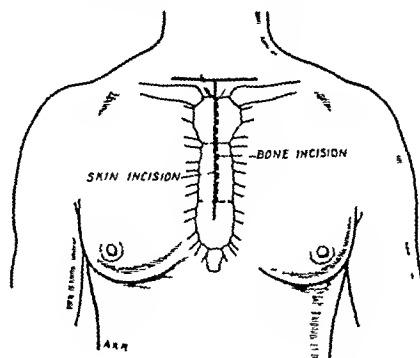


FIG 246 —The skin and bone incisions

above the sternal notch, and vertically over the centre of the manubrium and body of the sternum

2 The skin incision (Fig 246) is made in the same lines Above the sternal notch it is deepened to expose the attachments of the sternothyroid muscles Over the sternum the vertical incision is taken through the periosteum down to the bone, and extends as far as the level of the fourth costal cartilage In the earlier operations I went as far

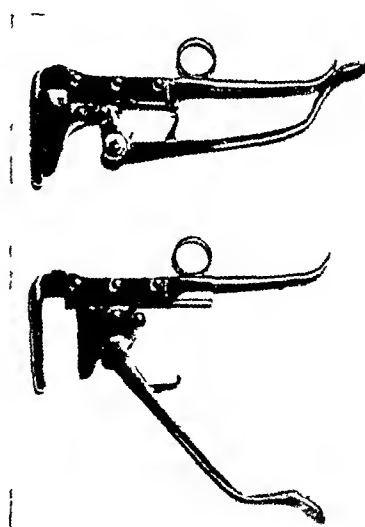


FIG 247 —Schumacher's sternum splitter

as the fifth cartilage in order to divide the sternum laterally into the fourth space Afterwards this seemed to be an unnecessary infringement of the integrity of the thoracic box, upon which the patient depends for the maintenance of breathing, and I now divide the sternum only as far as the fourth cartilage





(Photograph by Hennell)

FIG 248—The mediastinum opened

3 A short incision is made in the midline between the sternothyroid muscles, and the tissues are separated by blunt dissection, so that the left forefinger can be inserted beneath the manubrium sterni. The suprasternal ligament, usually accompanied by a blood-vessel, is divided. At this stage the upper horns of the thymus, which usually reach to the thyroid isthmus, can be readily demonstrated (Fig 250, inset), and these may be useful as a guide to the inexperienced operator in identifying the main bodies of the two lobes, but this is not essential.

4 The left forefinger is now pushed beneath the sternum, and the connective tissues of the mediastinum are separated from the back of the bone.

5 Small flaps of periosteum are raised towards the third interspace with a rugine which is cautiously passed to just beneath the edge of the bone in the interspace. A curved blunt dissector is next passed into the mediastinum to separate the pleura from the bone without injury, and this is made to meet the finger exploring from above.

6 Schumacher's sternum splitter (Fig 247) has seemed to be the most convenient instrument for cutting down the sternum, and the lower blade is now introduced underneath the sternum. It is removed when the central split has reached the level of the fourth cartilage, and the bone is then cut outwards on either side into the third spaces, a suitable pattern of rib-shears being used for this.

7 A strong self-retaining retractor is then put in place so as to lift and separate the two halves of the sternum. Bleeding during the process of sternum splitting is usually not severe, but if it seems excessive some Horsley's wax can be rubbed into the edges of the bone to control it.

8 When the mediastinum is exposed (Fig 248), all the structures are still covered with a layer of connective tissue, and no details can be made out. This film is divided with scissors strictly in the midline, and the two lobes of the thymus gland, pinkish yellow, smooth, and firm, come into view. The pleura is closely applied to both lobes of the gland, and often covers them completely. This is peeled away with the utmost care, so as to leave both pleurae intact if possible, and the full extent of the gland is gradually revealed (Figs 249, 250). Often the lobes extend some distance around the sides of the aorta, and so come to lie right underneath the lungs. In the upper part of the mediastinum the lobes lie on the left innominate vein whence the upper horns extend into the neck. Below, the lobes spread out in thin sheets on the surface of the pericardium to which they find a firm attachment. They are separated by blunt dissection from all these structures, blood-vessels are clamped and tied with the finest catgut, and the gland is removed. It is usually impossible to identify with any certainty the branches supplying the gland from the internal mammary arteries, because they are so small. Bleeding is avoided by clamping and tying any likely-looking strands of tissue. The venous drainage of the gland is concentrated in two large vessels.



(Photograph by Hennell)

FIG 249—The thymus gland dissected

running on the back of each lobe. These unite into one short trunk (*Fig 251*), usually of considerable size, which drains the blood into the front of the left innominate vein. This thymic vein is invariably present, and is a possible source of dangerous bleeding unless it is securely tied. It must therefore be identified with certainty every time.

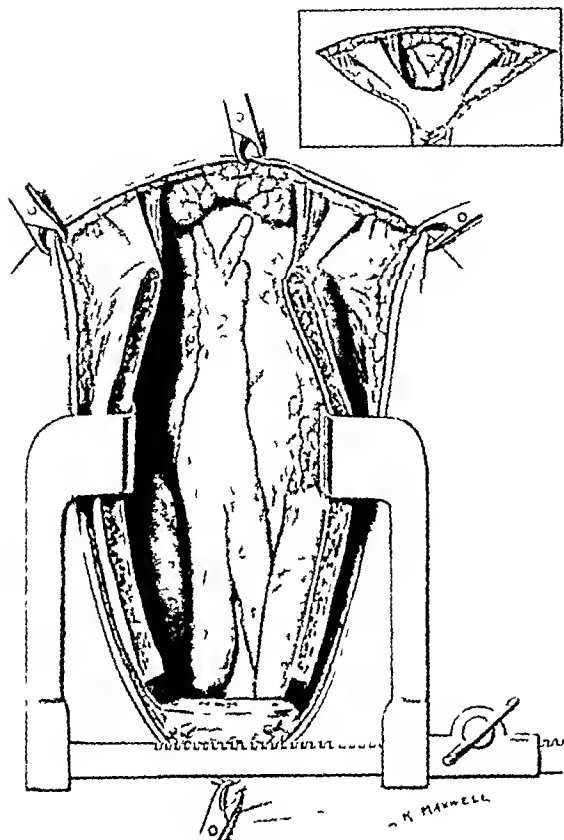


FIG 250—Drawing of dissected thymus

9 This dissection should have exposed all the mediastinal structures already mentioned, and they should be left clear if the whole of the thymus gland has been removed (*Figs 252-254*). The retractor is now taken out, the two halves of the sternum are allowed to spring back into their proper places, and the soft tissues over them are securely sutured in two layers with interrupted sutures of strong catgut. As Dunhill pointed out long ago, it is not necessary to fix the sternal halves with any special sutures through the bone, since they are held firmly enough by sutures superficial to the bone. This cancellous bone heals very rapidly, and only in one patient has non-union been observed. Approximation of the bone edges is made easier by lifting the patient's shoulders forward during the process of suturing.

10 The skin is accurately closed with fine sutures and clips, and dressings are strapped over the wound. It is important not to use any sort of bandage, since the maximum excursion of the chest must be maintained after operation.

The anæsthetic, given to my patients by Dr. Frank Evans and Dr. L. H. Morris, is a pentothal

induction followed by cyclopropane or gas and oxygen. The intrathoracic pressure must be fully controlled throughout the operation, and an intra-tracheal tube has been used for most of the patients.

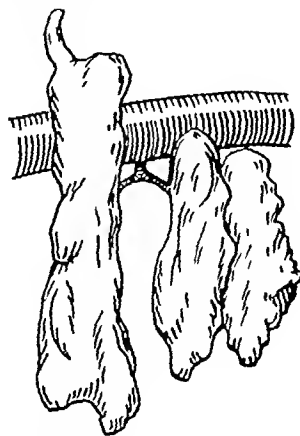


FIG 251—Showing the venous drainage of the thymus

It is probably better, however, not to use the tube if the anæsthetist feels confident he can do without it, since this eliminates one source of tracheal irritation and mucus secretion.



(Photograph by Hennell)

FIG 252—The gland removed

Though the operation was described by Blalock as a tedious one occupying 1½-2 hours, I have found that it takes, without any hurry, an average of 60 minutes. Experience has shown that post-operative shock is not severe, and there is no necessity for great speed.

The anatomical points which may be emphasized are (1) The invariable presence of the large thymic vein draining into the left innominate, (2) The close union between the lobes of the thymus and both pleural membranes, (3) The extension of the



(Photograph by Hennell)

FIG 253—The appearance of the mediastinum after removal of thymus

thymus far downwards over the pericardium and its firm attachments in this region. These three points serve to demonstrate the folly and danger of attempting to remove the thymus gland through an incision over the suprasternal notch without splitting the sternum. This operation was done by Sauerbruch in 1911 and has been repeated even in recent times, but it is unlikely to be practised in the future.

### THE THYMUS GLAND

It will be of interest at this point to consider in more detail the size, weight, and conformation of the thymus gland in the living adult subject. Ideas have been vague hitherto because the gland is not easy to identify in the dead body at post-mortem, and is almost impossible to isolate in its shrivelled state as found in the ordinary dissecting-room body. Furthermore, it has frequently been stated that the thymus is "abnormal" or "enlarged" in 50 per cent of the myasthenic patients who come to the post-mortem table, although it was very uncertain what was the normal size of the gland in adults, so that comparison was difficult. Careful investigations by Bratton (1925), Young and Turnbull (1931), and others, seem, however, to have established (1) that the thymus is *relatively* largest just before birth, and that from this point it does not grow in

proportion to the rest of the body, (2) that it is *actually* largest about the age of puberty, and gradually shrinks during the rest of the individual's life. Yet it is by no means so shrunk in normal adults as has been supposed, and it may weigh as much as 10–20 g even up to the age of 30 or after. It does undoubtedly decline in old age, and since most dissecting-room bodies are those of aged people, the notion of the thymus being a thread-like organ has naturally gained currency.

The systematic removal of thymus glands from myasthenic patients has now shown that it is not, as a rule, grossly abnormal in this disease. It is always there, and can be readily identified. Occasionally it is very large. I have removed one weighing 31 g from a man aged 37. On the other hand, another, from a woman of 36, weighed 2.7 g. But usually it is within the limits of normal. The average weight of 36 glands from myasthenic patients has been 15 g. The total weight of the gland has in any event no particular import in relation to disease. It usually consists to a large extent of lymphoid cells, connective tissue, and fat,

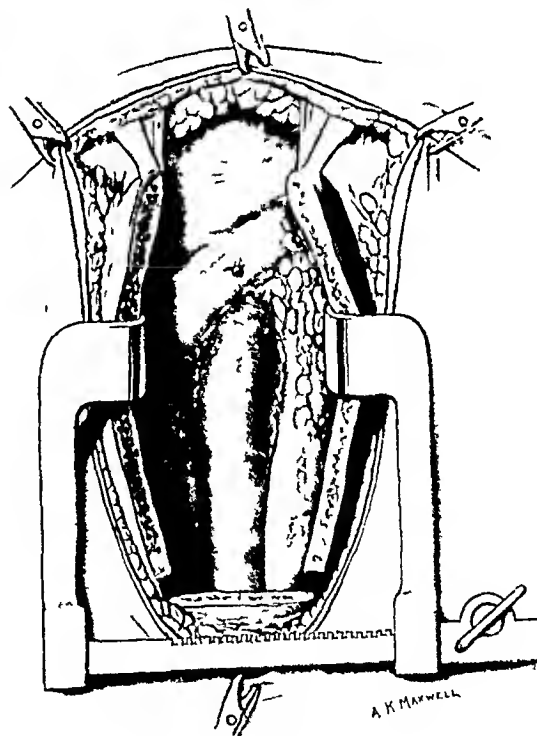


FIG 254—Drawing of the appearance of the mediastinum after removal of thymus

whereas its activity presumably depends on the proportion of active epithelial cells, invisible to the naked eye, which do normally decrease after the age of 25.

The thymus is an elongated bilobed organ, extending from the thyroid isthmus to the pericardium. It may be as much as 8 or 9 in long. There are varying degrees of union between the lobes in the midline. Apart from this there is very great variation in details of shape, as can be seen from the diagrammatic records of all the glands removed.

(Fig 258) The anatomical relations of the gland already described are fairly constant, though in the first patient I operated on the right lobe lay behind the left innominate vein instead of in front of it (Fig 255), and in the twenty-fourth patient the whole gland lay behind this great vein (Fig 256), making its removal a little more difficult



FIG 255—Showing the right lobe of the thymus lying behind the left innominate vein instead of in front of it

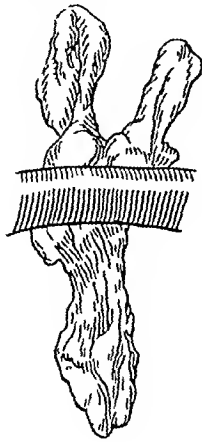


FIG 256—Case 24. Showing the thymus gland lying entirely behind the left innominate vein

### THYMOMAS

Reference has already been made to the occasional association of a thymic tumour with myasthenia gravis. This association has an important bearing on the treatment of myasthenia by thymectomy, experience having shown that any myasthenic patient may have a thymoma, often unsuspected. Blalock (1944), in his recent review of 20 patients treated by thymectomy, reported that he had found a benign tumour on 2 occasions. Both of these were successfully removed, and the patients were greatly benefited, one being apparently quite cured. The incidence of tumours in my series is approximately the same, 51 patients having produced 6 tumours. It seems, therefore, that at least 1 in 10 of the patients coming to operation is found to have a tumour, and the implications of this fact are of considerable importance. Both Blalock's tumours were benign, but of my six tumours one was already infiltrating the pericardium, pleura, and lung, and was judged to be inoperable. The patient died soon after the operation, and was found at autopsy to have compression of a main bronchus. It was evident that she could not have survived for very long in any event. The other five tumours were apparently benign, though their thick capsules were densely adherent to the pleura covering them and to the pericardium, thereby increasing the difficulty of removal and the risk of the operation, since it may be impossible to avoid opening the pleura widely. Thoracic surgeons do not regard opening the pleura as in any way affecting the outcome of their operations, and it is, in fact, part of their routine procedure. Myasthenic patients, however, have a very much smaller margin of respiratory reserve than other people, as well as a tendency to excessive secretion of mucus, and even a temporary collapse of the lung is to be avoided if possible.

One of my five patients with benign tumours died after the operation from atelectasis of the lungs. The other four survived the operation, but two of them, after improving very greatly for a time, had severe relapses of the myasthenia and died within three months of respiratory failure. Only two of the six tumour patients are alive to-day, one, two years later, is very much better than before the operation. The other was operated on only recently. These apparently benign tumours are, as I have said, thickly encapsulated, but, nevertheless, they show a tendency to burst through this capsule, and histologically they consist of a homogeneous mass of epithelial cells in a state of great activity. Their appearance suggests to me that the margin between innocence and malignancy is rather fine, and I feel sure that the removal of these tumours at as early a stage as possible is of the greatest importance to the patient's welfare. Two patients whom we judged to be too ill for operation died shortly after we had first seen them and proved to have tumours, one of them malignant. We have noticed that all patients with tumours tend to respond more slowly and incompletely than most to prostigmine. The tumour may be of large size. One of mine weighed 66 g with the thymus gland attached, and it is to be

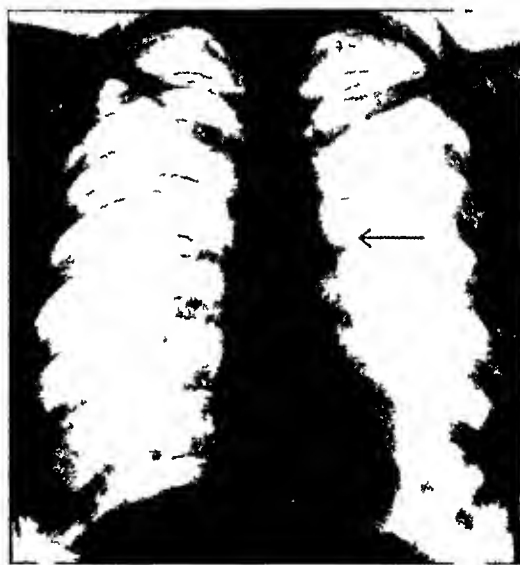


FIG 257—Radiograph showing shadow of thymic tumour (indicated by arrow)

expected that an encapsulated tumour of this kind would be demonstrable by radiography before operation. The ordinary myasthenic thymus can never be shown by X rays, being insufficiently opaque. The tumours can be demonstrated if they happen to overlap the shadow of the aorta, as is seen in one of my series (Fig 257), but if they do not do so it may be very difficult to detect them. Clearly, however, X-ray examination should be part of the routine investigation before operation. The 10 per cent incidence of these very actively growing tumours is also a point in favour of thymectomy in an early stage of the disease, since it may be possible to forestall their appearance by so doing. Our experience suggests that when they occur the prognosis becomes very bad indeed.

# RESULTS

All the 51 operations except one were done at the L C C Hospital, New End, Hampstead, where I have been assisted by Mr J E Piercy. The burden of almost the whole of the post-operative management has been borne by Mr Piercy and the nursing staff at New End, to whose skill and assiduity many of the patients owe their lives. Dr Carson

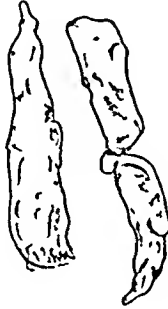
and I were anxious from the outset that the issue should not be clouded by any doubts as to the diagnosis of myasthenia gravis in every patient, and the great majority were carefully observed by the physicians at Queen Square before being transferred to New End for operation. Most of them were also subjected to the test of injection of prostigmine into the brachial artery. This strengthens the flexor muscles of the forearm in the myasthenic



Case 3 Weight 10 g



Case 5 Weight 8 g



Case 6 Weight 10 g



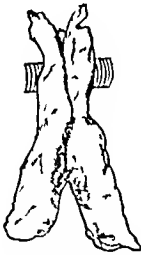
Case 7 Weight 7.5 g



Case 8 Weight 8 g



Case 9 Weight 12.5 g



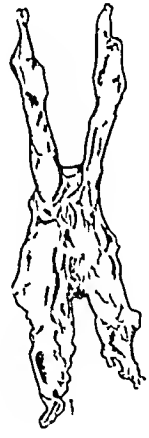
Case 10 Weight 16 g



Case 11 Weight 9.5 g



Case 12 Weight 31 g



Case 14 Weight 8.5 g



Case 15 Weight 19 g



Case 16 Weight 11.5 g



Case 17 Weight 5 g



Case 18 Weight 23.5 g



Case 19 Weight 11.5 g

patient, but has the opposite effect in the absence of myasthenia. We believe that there were no errors in diagnosis, and we avoided, moreover, operating on any patients whose disease was so mild that they were able to live an almost normal life with the help of prostigmine. All our patients, in fact, could be described as severe or very severe examples of the disease, and most of them were maintained on very large doses of prostigmine, with or without ephedrine.

The youngest patient was 15, the oldest 54. Of the 51 patients 4 were under 20, and 7 were over 40, so that 40 came into the two decades 21 to 40. The duration of the diseased state before operation varied from 20 years to 4 months. In three-quarters of the patients the history was 5 years or less.

Of the 51 patients operated on 13 are dead and 38 alive. I will first consider the operative mortality. It must be realized that myasthenic patients present



Case 20 Weight 10.5 g



Case 21 Weight 21.5 g



Case 23 Weight 9.5 g



Case 25 Weight 20 g



Case 26 Weight 14.09 g



Case 27 Weight 12.5 g



Case 28 Weight 18.5 g



Case 29 Weight 2.7 g



Case 30 Weight 23.5 g



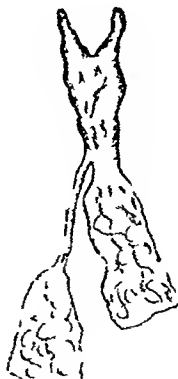
Case 31 Weight 13.5 g



Case 32 Weight 20 g



Case 33 Weight 21 g



Case 34 Weight 18 g



Case 35 Weight 21 g



Case 36 Weight 17 g

no ordinary problem in post-operative treatment. They are often greatly debilitated, their respiratory and cough muscles are often very weak—they may have difficulty in eating and swallowing. They are extremely susceptible to pulmonary infections, and apart from this are prone to have respiratory crises in which thick mucus collects in the bronchi and cannot be expelled. Sometimes they secrete floods of frothy mucus in which they seem almost

operative mortality of 16 per cent, but it is perhaps misleading to regard this figure as representing the risk of operation in our hands at the present time, for scrutiny of the list in chronological order shows that 7 operative deaths occurred among the first 21 patients, and only 1 in the next 30. This extraordinary drop in the incidence of deaths must, I think, be in part attributable to increasing experience both operative and post-operative. It cannot be

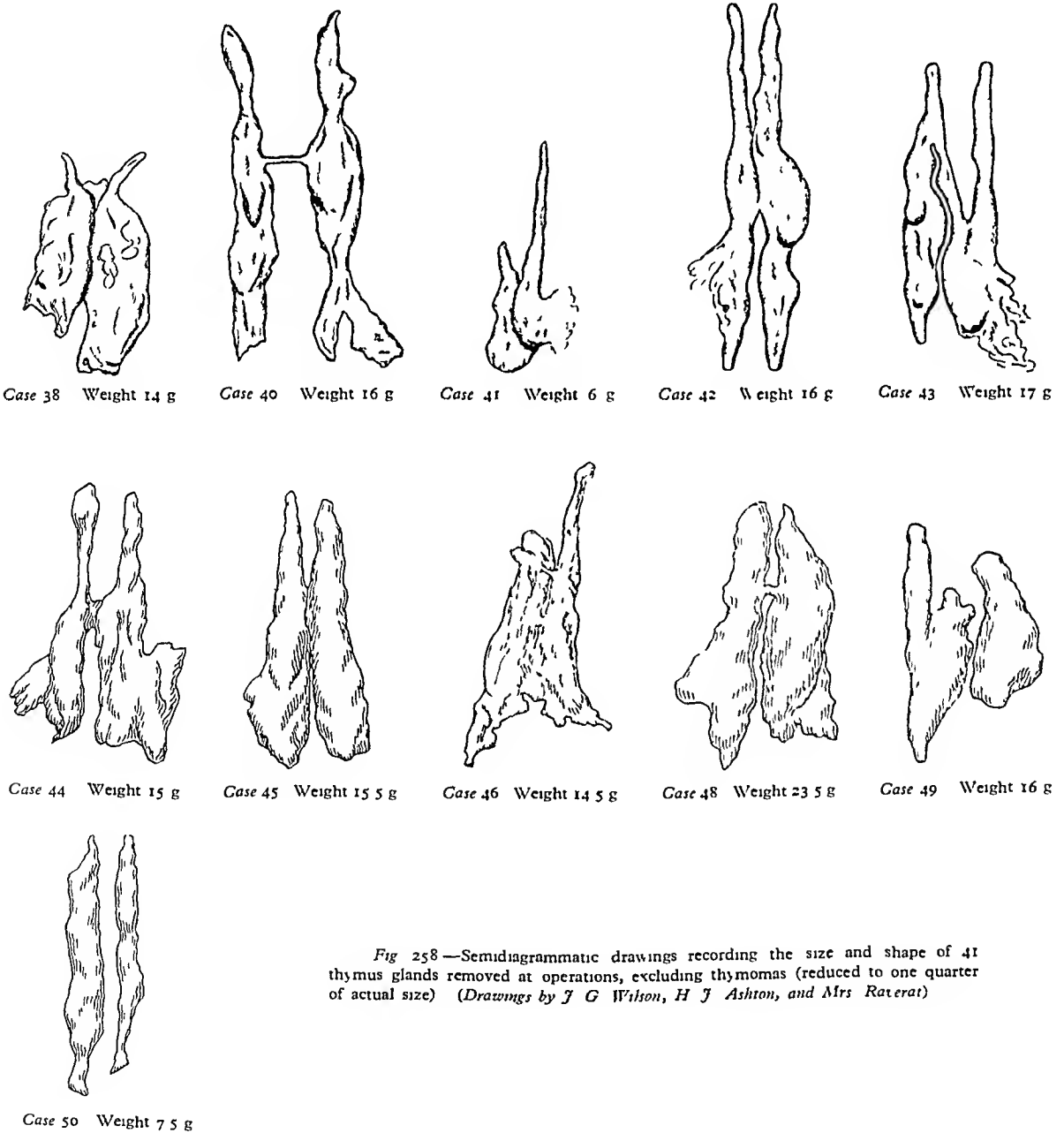


Fig 258—Semidiagrammatic drawings recording the size and shape of 11 thymus glands removed at operations, excluding thymomas (reduced to one quarter of actual size) (Drawings by J G Wilson, H J Ashton, and Mrs Raterat)

to drown. Occasionally they suffer from an associated thyrotoxicosis which may be very severe. Looking back on our series it is a matter of surprise to me that of the 13 who have died, only 8 could be called operative deaths. This might be called an

all luck, though it may be argued that ill fortune did attend our efforts at first, since among the first seven deaths after operation were patients with (1) a malignant tumour, (2) rheumatoid arthritis and brown atrophy of the heart muscle, (3) chronic



# SURGERY OF THE THYMUS GLAND

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bronchitis, and (4) delirium tremens. The eighth patient who died had thyrotoxicosis and brown atrophy of the heart muscle. It is very noticeable that the operative risk is greatly increased by age. Four of the eight patients were in the small group of seven who were over 40. The other five patients who have died at intervals after operation up to two years all succumbed to respiratory infections which are so characteristic of the myasthenic state. Before the effect of operation on the disease is assessed, four patients will be described in detail.

**Case 6**—A sailor, aged 22. Eleven months before we saw him he had noticed that speech became slurred after talking for a few minutes. A few weeks later he had difficulty in climbing ropes and ladders, and also developed double vision and difficulty in swallowing. The naval authorities then realized that he was not malingering, and he was invalided from the Service. He became rapidly worse, particularly in the evenings, and had to take 15 mg of prostigmine before each meal in order to be able to eat. Thymectomy was done in May, 1942, and though he showed an initial improvement, he relapsed badly a fortnight after the operation, and nearly died in an acute myasthenic state. He just scraped through, however, and six weeks after operation had improved so much that prostigmine was no longer necessary. From that time he has been perfectly well and leading a normal life. It is now over three and a half years since the operation.



FIG 259—Case 3 The patient after thyroidectomy and thymectomy

**Case 3**—A member of the National Fire Service, aged 34 (Fig 259). For nine months he had had pronounced symptoms of myasthenia which became rapidly worse, and for three months he had been quite helpless and bed-ridden. He was also acutely thyrotoxic with a pulse-rate of 130 and paroxysms of auricular fibrillation. We judged that the thyrotoxicosis must be dealt with first, and a partial thyroidectomy was done in May, 1942. He nearly succumbed to this, with auricular fibrillation and collapse of one lower lobe. He recovered, however, and six weeks later had no signs of thyrotoxicosis. The myasthenia, on the other hand, was worse, and he was very weak. He had recurrent respiratory crises with viscid mucus welling up from his lungs, and for these he had to have prostigmine given intravenously. Thymectomy was done in June, 1942. Rather to our surprise he survived this, and made steady progress, which has continued to the present time. He presented the unusual feature of partial atrophy of some muscle

groups, and this delayed his regaining strength, but now three and a half years after operation, he is quite well and able to lead a normal life without prostigmine.

**Case 14**—A fireman, aged 39. Twenty years ago he had noticed drooping of his eyelids, and was diagnosed as having myasthenia gravis of mild degree. In spite of double vision he was able to carry on his occupation



FIG 260—Case 14 Photographs showing patient before (A) and after (B) taking prostigmine

as fireman. Three months before he was seen he began to notice weakness of arms and legs, and he developed all the other characteristic signs of severe myasthenia gravis. Fig 260 shows him before and after having prostigmine, which he could not take by the mouth because of retching and colic. Thymectomy was done in January, 1943, but this had no effect whatever on the symptoms. The disease was in an irreversible phase, and he died three months after operation of bronchopneumonia.

**Case 37**—A farm foreman, age 34 (Fig 261). For two months he had noticed a rapid onset of difficulty in



FIG 261—Case 37 Photographs of patient before (A) and after (B) removal of the thymus

chewing and swallowing. He had to support his lower jaw with his hand. When admitted to hospital he had severe signs of myasthenia, particularly facial, which

responded well, though slowly, to prostigmine. Thy-mectomy was done in November, 1944, and he was found to have a thymic tumour weighing 66 g. This was removed, and he made a dramatic recovery, so that he was discharged from hospital a month later apparently almost well and free from symptoms (Fig 261). A week later, however, all his symptoms returned, and he died with acute myasthenia three months after operation. Nothing which could account for the relapse was found at the autopsy.

These four examples illustrate the extremes of success and failure, and there is much variation in between. We have had difficulty in deciding how best to classify the results, since there is no uniformity in the manifestations of myasthenia. It is easy to say if a patient is quite well, or if there is no improvement at all, but hard to assess intermediate states. We have in the end decided to recognize four categories —

- A Quite well, normal life without prostigmine
- B Greatly improved, but needing some prostigmine
- C Somewhat improved, prostigmine less than before
- D No improvement

Of the 51 patients operated on 18 cannot be included in the results because of —

Post-operative deaths	8
Mentally abnormal	1
Too recently done	9
	<hr/> 18

Thus, there are 33 to be classified, and a careful follow-up gives these results —

A Well	9
B Greatly improved	11
C Somewhat improved	8
D No better	5

It is noticeable that all the patients in group A had short histories, the longest being two years, those in group D had long histories (6, 9, 20 years), or a tumour (2 patients), those in group C had long histories (4 to 16 years), or a tumour (1 patient), those in group B had histories varying from 4 months to 6 years, but more were short than long.

These observations seem to provide some answer to the questions that naturally arise as to prognosis. In brief, it is the younger patients with the shorter histories who will give the best response. Patients have now been apparently cured for as long as three years, so there seems to be some hope that the results may be permanent.

### HISTOLOGY

The histology of the thymus gland is being investigated in detail by Dr Collins, of Sheffield, and Dr Bratton, of the L.C.C. Service. Glands, both from normal adults and from myasthenic patients, are being examined, and it has not been easy to detect any constant difference between them,

but the investigators believe that they are now finding in most of the myasthenic glands an abnormal development of foci of clear cells resembling the so-called germinal centres of lymph-glands. It is just possible that these cells are derived from the epithelial elements of the embryonic gland, and that they are the real culprits producing the poisonous secretion responsible for myasthenia gravis. The Hassall's corpuscles, so conspicuous in all thymus glands, are likely to be innocent of all evil. The tumours removed consist of solid masses of large clear cells, also probably of epithelial origin. These matters will be reported on in detail at some future date.

### BIOCHEMISTRY

In the future, too, lies the full investigation of myasthenic thymus glands by biological assay. The glands removed are being kept in cold storage against the time when Dr Parks at the Mount Vernon Institute of the Medical Research Council will have time to devote to this problem. The investigation seems full of promise.

This paper describes a recent advance along one of the by-paths of surgery. Let it be remembered that seemingly unimportant by-paths may ultimately lead to main roads.

**Acknowledgement**—The colour photographs (Figs 248, 249 and 252, 253) were taken by Mr Percy Hennell of the Metal Box Company, working on behalf of the Medical Research Council.

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## CONSTRUCTIVE PERICARDITIS\*

BY T HOLMES SELLORS

SURGICAL intervention in disorders of the human heart is still regarded as something in the nature of a dramatic adventure, although in recent years it has been shown that the surgeon's hand is more kindly tolerated than was once thought possible. At the end of the last century Weill and Delorme were urging that in constrictive pericarditis 'c'est à la chirurgie qu'il appartiendra un jour de délivrer le cœur de la coque qui l'étrangle'. An occasional attempt here and there to free the heart from its trammels remained a surgical curiosity, and only in the past decade has it been accepted as a recognized procedure. Even now related experience is limited and variations of opinion exist in the surgical treatment of this crippling disease.

## HISTORICAL

The local evidence of pericardial constriction is associated with other changes in the body, both of primary and secondary importance. Pick's disease is a title frequently used in this connexion, though it has been shown that priority of description definitely belongs to Richard Lower (1669). He clearly recognized the syndrome with the failure of the heart to relax fully in diastole as being the principle factor in the defective cardiac output. He also noted an inspiratory suppression of the pulse (*pulsus paradoxus*) and gave an explanation of this phenomenon, thus antedating Kussmaul (1873), whose name is usually associated with this form of pulse, by more than two centuries. The work of two English physicians, both from Guy's Hospital, also merits a recognition that has only recently been accorded it in American literature. Chevers (1842), from his post-mortem records, found no evidence of rheumatic origin in the pericardial adhesions whose contraction round the heart leads to "compressing its muscular tissue and embarrassing its systolic and diastolic movements, but more particularly the latter". Wilks (1871) noted that "in a well-marked case of disease with cardiac symptoms in young persons without any valvular bruit pericardial adhesions may be fairly expected". Other early references have been dealt with in Herrick's *Short History of Cardiology* (1942) and in the works of Paul White (1944).

The frequent use of the name of Pick (1896) in connexion with constrictive pericarditis is the outcome of a series of cases in which he differentiated between liver cirrhosis associated with and resulting from pericarditis and the enlarged icing-sugar liver which occurs in cases of polyorrhomenitis (polyserositis). About the same time the possibilities of active surgery were being considered by Weill (1895) and Delorme (1898) in cases of definite constriction. The study of the adherent pericardium which led up to Broadbent's classic description (1895) did, however, lead to considerable

confusion, not yet fully clarified. The type of case with an enlarged heart, fixed apex beat, systolic recession, and diastolic shock should come under the heading of mediastino-pericarditis and be in no way confused with constrictive pericarditis. The whole picture of these two conditions is almost diametrically opposed, the only common factors that they possess being a pericardial pathology and interference with circulatory function.

The first surgical attempts to obtain freedom of action for the restricted heart were based on Brauer's operation of cardiolysis, in which costal cartilages and part of the adjacent sternum over the left heart were excised. Bourne (1924) recorded at least 25 cases and Smith and Liggett (1929) 107 instances of this operation, though the condition for which operation was undertaken was not one of pericardial constriction in the strict sense of the term. It seems probable at the present time that the Brauer type of operation has little place in cardiac surgery and none in constrictive pericarditis, though it is admitted that it may constitute the approach stage for the operation of pericardiectomy.

Constrictive pericarditis which ties down the heart movement and produces chronic compression can only be relieved by some direct form of excision of the cicatrized pericardium. Among early attempts at this type of surgery already advocated by Delorme were those of Rehn, Hallopeau and Sauerbruch, but the first comprehensive series of cases was published by Volhard and Schmieden (1923-6). The work of these last constituted the real foundation on which the present understanding and treatment of the condition is based. Churchill's first case in 1929 afforded considerable stimulus to the English-speaking world, and figures and accounts have been published by Blalock and Burwell, White, Churchill, Beck, Heuer, Harrington and others.

## GENERAL PICTURE

By definition the essence of constrictive pericarditis lies in the fact that contraction of pathologically formed intrapericardial adhesions restricts the normal action of the heart. It is well known that adhesions can exist without obvious interference with function, on the other hand extrapericardial adhesions dragging on a diseased heart may add to its enlargement. At this point it is advisable to emphasize again the precise differentiation between the constrictive and non-constrictive forms of adhesion. Armstrong (1940) examined 114 collected post-mortems with extensive pericardial adhesions and found that in those cases (72 in number) in which the heart was enlarged there was evidence of some definite cardiac lesion. Compression of the heart was only recognized in 10 instances and here the adhesions were of such a type that they constituted a strong fibrous cuirass round the heart. Severe myocardial damage rarely, if ever, occurs in constrictive pericarditis.

\* Being based on a Hunterian Lecture delivered at the Royal College of Surgeons, April 28, 1944.

Starting then with a constricting and limiting layer of dense fibrosis in the pericardial tissues, it is possible to see how increasing contraction brings about progressive impairment of cardiac function. The heart is practically strangled to death by cicatrization of its own investment.

The chief effect of the fibrosis is to limit diastole. The oncoming venous blood cannot be accepted in full amount by the restricted relaxation, and the pump, being insufficiently supplied, has less to deliver in its forcing stroke. It has not been universally recognized that the heart chambers are unable to receive the full amount of venous blood offered them. It has been suggested that constriction by scar tissue round the great veins could reduce the venous return and limit the heart output in this way; this supposition is probably erroneous and was based on the presence of narrowing and calcification round the caval orifices. It is possible that these channels can be reduced to a diameter of little more than a lead pencil without interfering with an efficient circulation, providing that the ventricles are sound, moreover, the improvement obtained by freeing only the ventricles suggests that their compression is the main factor in the production of the condition. In mechanical terms, then, the cause of the mischief lies in the fact that as the filling stroke of the piston is shortened the compression stroke cannot deliver its normal output, and in consequence the pressure in the supply 'main' will inevitably rise.

On the arterial side of the circulation the limitation of diastolic supply and consequent reduction of systolic output is recognized by a low level systolic blood-pressure (90 to 110 mm Hg) and a low pulse pressure (15 to 25 mm Hg being not unusual). In normal circumstances the response to exercise results in an increased output of the heart per beat associated with some increase in rate, factors which combine to give a substantial increase in the volume output per minute. In constrictive pericarditis the output per beat is limited and the only way in which the necessary volume per minute can be sustained is by an undue increase in the pulse-rate. Tachycardia is therefore a comparatively early sign and this becomes even more prominent on exertion. Dyspnoea similarly occurs on exercise, but is absent at rest, and does not occur when the patient is lying flat (an important sign in differential diagnosis). The presence of a paradoxical pulse is common and whereas a simple mechanical explanation as suggested by Lower may be adequate, a circulatory theory of causation as offered by Hitzig (1941-2) is also acceptable.

The effects on the circulation in constrictive pericarditis and other conditions producing chronic tamponade have been studied by Blalock and Burwell (1941), Heuer and Stewart (1939), and Hitzig (1941-2), with results which conform with most findings. The velocity of the blood-flow is reduced, the normal figure of 16 to 21 seconds between arm and tongue being prolonged up to 40 or 60 seconds. The heart output is definitely lowered to about 2 litres per minute (normal 3.87) and the output per beat may be reduced from 64 c.c. to 18 to 40 c.c. The blood-volume in the few instances in which it has been measured shows an increase

of 30 to 40 per cent above normal. The oxygen content of the arterial and venous blood has also been estimated and the difference has been found to be exaggerated in constrictive pericarditis.

The most significant feature of the condition is the raising of the venous pressure—a direct response to the reduced heart output. Volhard referred to the phenomenon as *Einfluss Stauung*, which has been inadequately translated as Inflow Stasis. The venous return steadily becomes dammed back and, whereas a raised venous pressure may be of some help towards an improved output, the effects on other parts of the body are more far-reaching. In acute cardiac compression or tamponade, as Beck has pointed out, pressure on the heart which gives rise to a figure of 160 mm water in the right auricle and cave is the point at which the circulation stops. In chronic compression the venous pressure can reach as high as 300 mm or 400 mm, and the slow development of the stasis allows the peripheral systemic veins to become dilated and even tortuous. These veins appear on all parts of the surface and are particularly noticeable in the neck, head, and abdominal wall. Venous pulsation is an associated feature and its presence excludes venous obstruction as a cause of the distension. The actual pressure may be measured by observing the height to which blood will rise in a tube containing citrate solution connected through a needle to an antecubital vein. This vein should be held at the same level as the auricles, regardless of the posture of the patient. The venous signs in the neck are among the most important in the recognition of the condition and the approximate assessment of its severity. In the normal subject reclining at an angle of 45°, the external jugular veins are not distended, nor is pulsation in the deep veins visible above the supraclavicular fossa, since the level of the venous reservoir is about that of the angle of Louis. With the rise in venous pressure consequent on compression of the heart, the level in the venous reservoir rises, and thus the point to which the veins of the neck are distended. The measurement of increased venous pressure by taking the vertical height above the sternal angle of the pulsating junction between the distended and collapsed segments of the external jugular vein is a simple procedure.

Peripherally the effect of venous engorgement is most obvious in oedema in the dependent parts of the body particularly in the legs, where in course of time the oedema takes on a lymphatic appearance. Facial and arm oedema may be present though they are not always noticeable, but swelling of the face has been seen to develop in the course of days when rapid constriction was occurring (Case 4). Cyanosis of varying degree is common and the extremities are blue, cold, and uncomfortable. These symptoms are out of proportion to the degree of dyspnoea, being more dependent on the raised venous pressure than on the unduly reduced cardiac output.

The organ on which the effects of the venous stasis are most marked is the liver. Liver enlargement with ascites is one of the cardinal signs of constrictive pericarditis, both are proportionally much greater than in a comparable case of congestive heart failure. Apart from other significant signs the enlarged belly is almost bound to attract attention,

and it is a salutary criticism on diagnostic ability that some cases which ultimately came to pericardiectomy had been previously submitted to Talma-Morrison types of operation for persistent ascites. The reason for the fact that the effects of raised venous pressure should fall so heavily on the liver may be in part due to the absence of valves in the main hepatic veins. This, however, does not account for the relatively greater engorgement in comparison with congestive heart failure, and it has been suggested that basal cardiac adhesions hold the orifices of the hepatic veins wide open, thus exposing them to the full brunt of the raised venous pressure. The enlargement of the liver may be so gross that the lower edge is below the level of the umbilicus, and when long-standing in a child may produce a marked 'pot belly' and outward winging of the costal margin. Where palpable, the liver is soft and occasionally tender. In the later stages perihepatitis produces an icing-sugar appearance, and the peritoneum shows thickening. Upper abdominal discomfort, fulness, anorexia, and in some cases pain are possibly attributable to the liver enlargement. In advanced cases in which there has been time for the raised venous pressure to damage liver tissue the loss of function may contribute to the failure of complete recovery that is sometimes seen after apparently successful excision of the constricting pericardium. The spleen is rarely enlarged and there is little evidence of interference with renal function.

The ascitic outpouring can reach considerable proportions, as has been indicated, and presents in many cases the characters of a transudate. It is possible, however, that a coexisting inflammatory exudate may also be present as the result of peritoneal irritation. In one case in the present series the finding of tubercle bacilli in this fluid afforded direct evidence of this point, and it is probable that in many instances of multiple effusions with cardiac compression the ascitic fluid is a combination of a transudate and exudate. The rate of re-accumulation after paracentesis is variable, dependent to some extent on fluid intake, diet, and drug administration, but on the whole fluid is formed most rapidly in the early stages while the constriction is developing. In later years thickening of the serous membrane appears to delay fluid production.

Other effects of less clinical significance include raising of the cerebrospinal fluid and lymphatic pressures. Effusion into the pleural cavities is generally accepted as part of the constriction complex, but our observations suggest that a pleural transudate is extremely rare and that the effusion has the character of an inflammatory exudate, being often unilateral and transitory. In other words, pleural effusions are probably part of a polyserositis (polyserositis), rather than a sequel to constrictive pericarditis.

A remarkable feature in all this interference with the circulatory system is that the lungs are unaffected. Admittedly the pressure from the abdomen reduces their capacity to a small extent, but congestion is, clinically and radiologically, absent. The explanation is that the restricted diastole of the right ventricle allows only a limited output of blood into the pulmonary vascular bed, and this amount is easily

dealt with by the left heart without raising the venous pressure in the lungs. This has a definite bearing on the surgical technique of pericardial excision, for if the right ventricle is liberated before the left the suddenly increased output into the lungs may lead to severe pulmonary congestion, since the limited stroke of the left ventricle cannot accept the greater volume from the lungs. Congestive heart failure, be it noted, is invariably accompanied by some pulmonary engorgement and occasionally hæmoptysis, so that the presence or absence of these features is important in differential diagnosis.

Such symptoms as lassitude, wasting, and weakness are regularly encountered and can be understood in the light of the general interference with the circulation. The rate of development of the constriction plays a considerable part in establishing the symptom complex. A gradual onset in middle age may be associated with vague complaints, such as tiredness and slight shortness of breath with dyspepsia, but a more acute course in a child leads to rapid loss of weight, distress, coldness, and a general arrest of development.

In summary it may be said that the essential features of chronic cardiac compression are based on the increase in the venous blood-pressure, with consequent engorgement and œdema. Ascites and an enlarged liver are constant findings. To complete the classical triad of the compression syndrome, according to Beck, a small quiet heart should be added. This, however, requires qualification, since a reduction in the apparent size is by no means always seen, but the presence of a 'quiet' or practically immobile heart can be emphasized.

## STATE OF THE HEART

One of the fundamental points of constrictive pericarditis is that the heart muscle is normal in nearly every case. The myocardium is not diseased and it is potentially sound, though its activity has been sorely restricted in the process of constriction. If the restraining pericardium is removed the myocardium in the course of time is able to function with a power that approaches normal. Moreover, the condition only embarrasses the patient's existence when the local mechanical state has jeopardized the circulation as a whole.

Some evidence has been advanced to suggest that disuse atrophy of the myocardium may possibly result from prolonged constriction of the muscle-fibres. A postural 'contracture' might almost be expected, but the only direct evidence is provided by Roberts and Beck (1941), who found that the average diameter of the heart muscle-fibre (in a few post-operative hearts examined) was reduced from  $13.9 \mu$  to  $9.9 \mu$ . It has further been suggested that the constricting fibrous tissue may produce narrowing of the coronary vessels with subsequent atrophy of muscle, but in our investigations this has not been apparent (*Fig. 262*). It seems probably that after successful pericardiectomy the muscle power is not up to its normal standard, but in the course of the months the muscle strength re-develops.

Whereas the heart muscle itself is relatively normal the same cannot be said about cardiac rhythm. The presence of contracting scar tissue

and even plaques of calcium around the 'pace-making' area may account for irregular stimulation. All types of irregularity from occasional extrasystoles to established auricular fibrillation may be

hours. Any pre-existing irregularity is not necessarily replaced by normal rhythm after surgical removal of the pericardium, though it has been so on rare occasions. In one of our cases (*Case 2*)



FIG 262—Section through a branch of the coronary artery. A, Normal, B, Constrictive pericarditis (*Case 3*). The subject from which A was taken was two years older and of appreciably greater stature than the subject of the pathological specimen.

encountered and periodic changes of rhythm are not uncommon. Operative handling of the heart produces extrasystoles and sometimes fibrillation, though these disturbances, even if they are more than transitory, generally subside within twenty-four

alternations of flutter and fibrillation were observed between periods of normal rhythm.

It is commonly presumed that the heart is small and immobile as a result of constriction, and in most established cases this is so, but in early constriction the added thickness of the pericardium may even give an impression of enlargement (*Cases 1, 4*). It is important to realize that one of the three supposedly cardinal signs of chronic cardiac compression, viz. a small heart, cannot be relied on.

The diminished range of movement of the heart is similarly not always obvious. Admittedly the apex-beat is rarely to be felt and the heart-sounds are distant and obscured, but a palpable apex-beat and audible heart-sounds are not incompatible with constrictive pericarditis. Murmurs are rare, but when calcification has occurred some adventitious sounds may be elicited, e.g., the high-pitched protodiastolic vibration of Lian. The range of heart movements can only be assessed by radiology, where screening and kymography are both of value. Screening gives a most accurate picture, since all available aspects of the heart outline can be viewed, kymography gives a more permanent record which can be examined and analysed at leisure. All borders of the heart must be observed for pulsation and it will probably be found that the limitation of movement is not uniform. A fixed left heart border, for example, may be accompanied by some movement of the right border, which, however, is in reality a thrust on to the weakest area of the constricting tissue. Undue elevation of the diaphragm and pleural effusions may add to the difficulties of screening, but our experience shows that screening is an imperative part of diagnostic investigation. An increased width at the upper part of the heart shadow is always to be seen, owing to engorgement of the superior vena cava and innominate veins. Other radiological points to be noted are calcification in plaques or bands,

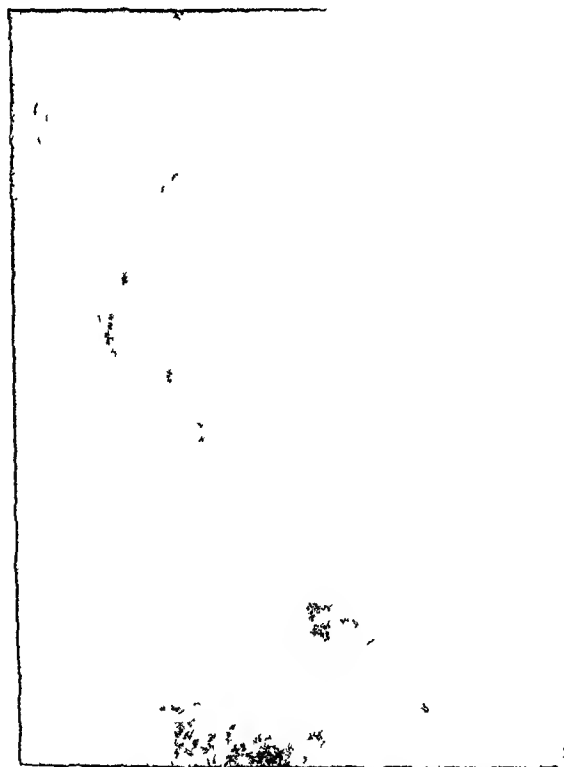


FIG 263—Calcified constrictive pericarditis (*Case 5*). Calcium forming an irregular meshwork round the aortic arch and great veins is more visible in the lateral than anteroposterior views.



reduced excursion of the aortic arch, and raising of the heart on swallowing (the swallowing sign of Rabin). Calcification appears in a quarter to a third of all cases, and films in different angles and of different penetrations may be necessary to demonstrate its presence (*Fig 263*). It must be remembered that calcification of the pericardium can occur without constriction.

Electrocardiography shows remarkably uniform results, the principle features being a low-voltage type of curve and lowering or inversion of the T-wave (*Fig 264*). The loss or inversion of the T-wave is commonly seen in Leads I and II and contrasts with pericardial effusions, which exaggerate

(1935), in reporting one of Churchill's operation cases, found tuberculous tissue in the original specimen, but on re-operation at a later date the excised pericardium showed only fibrosis. The significance of this observation should not be overlooked. Blalock and Burwell (1941) have admitted tuberculosis as a dominant factor in their series of cases, but generally tuberculous infection is only accepted as a positive aetiological factor in a small proportion of cases. Our own evidence strongly supports tuberculous infection as the chief causative agent, an opinion based on general clinical grounds, on the evolution of the condition, and on pathological evidence. Out of 5 operation cases

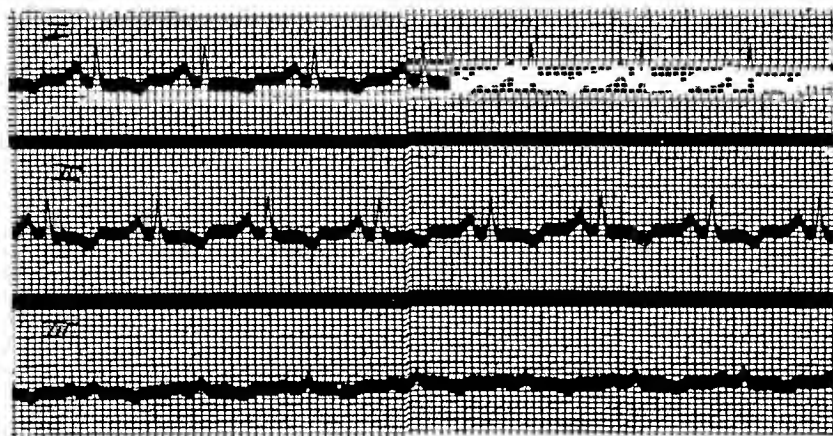


FIG 264—Electrocardiogram from case of established constrictive pericarditis. Note low-voltage curves and inversion of T-waves.

RS-T and the T-wave. Investigations of electrocardiographic changes have been made during operation (Stewart and Bailey (1941), but there is little to suggest that there are any notable changes apart from alterations in rhythm. After pericardiectomy there is some improvement in the voltage and a tendency for the T-wave to become less flat or inverted, but this is not marked for some time after effective liberation of the heart.

**Aetiology and Pathology**—Rheumatic fever must be excluded from any share in the causation of constrictive pericarditis. The post-mortem studies of Wenkebach (1907), and Smith and Willius (1932) have revealed a high incidence of pericardial adherence which is of rheumatic origin, but that this type of adhesion does not lead to constriction is confirmed by observation over years (Chevers, 1842, White, 1935) and by pathological observations by Armstrong (1940) and the writer. The rheumatic adhesion is thin and vascular with loosely packed wavy collagen fibres. It is not the heavy hyaline collagenous type which heralds cicatrization and contracture.

Current literature submits three possible causes for the origin of constriction—tuberculous infection, old pyogenic pericarditis, and idiopathic factors. This last accounts for the largest group in the published records, but it is easy to understand that the limited tissue available for microscopical examination from pericardial excision and the duration of the disease fail to afford complete facilities for investigation. It is interesting to note that White

and 15 others observed, tuberculosis was evidenced in 16. The massive avascular collagen of extremely hyaline character in long-established cases suggests that the condition is the end-result of a widespread and devastating inflammation with great destruction of tissue. This picture is similar to that seen in advanced healing stages of tuberculous inflammation and is strong evidence (in the absence of more direct findings) of this infection (*Fig 265*).

A small number definitely owe their constrictive origin to a suppurative pericarditis. Many cases of staphylococcal infection which have been adequately treated, go through life with no further evidence of trouble, but where there has been insufficient aspiration or drainage and the patient has survived, the possibilities of constriction supervening at a later date are considerable. In this group the constricting membrane appears to be unduly thin, uniform, and tough, and calcification is not recorded.

The effect of chronic pericardial inflammation is most marked—as in the case of the pleura—on the parietal layer in the initial stages, but—again comparable with pleural inflammation—it is the restricting influence of the thinner visceral layer which is functionally more important. Pockets of fluid or inspissated pus and debris are often present. Plaques of calcium tend to burrow into heart muscle, and these, though of relatively minor importance over the thick-walled ventricles, are potential sources of danger elsewhere. Adherence of epicardium to muscle in the various grooves of



the heart (auriculo-ventricular, line of coronary vessels) is firmer than in other parts, and the development of fine blood-vessels between muscle and pericardium accounts for the punctate hæmorrhages that are encountered at operation

**Development of Constriction**—In a few patients it has been possible, over a long period, to watch the actual production of pericardial constriction. These came under observation long before the syndrome developed and in two instances

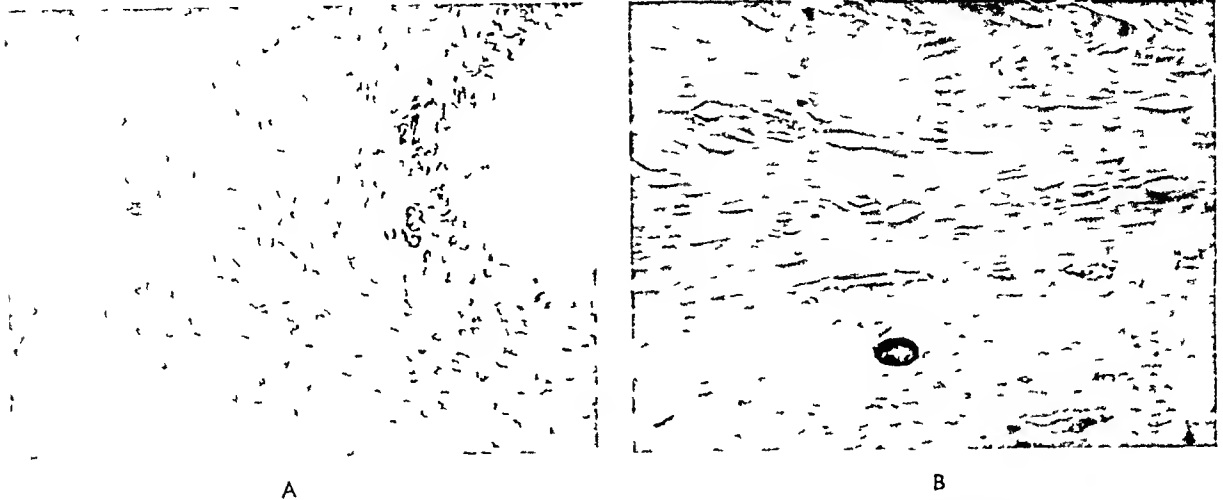


FIG 265—Microscopic appearances of excised constrictive pericardium. A Tuberculous, showing vascularity, tubercle systems and large giant cells (Case 3). B Fibrosis of no definite origin. Avascular tissue with hyaline collagenous bundles (Case 2). ( $\times 50$ )

Extreme fibrosis around the caval and auricular regions is occasionally seen, and has already been mentioned as the site, according to some writers, at which obstruction to venous inflow occurs. It

showed extensive pericardial effusions, suspected but not proved to be of tuberculous origin. Associated tuberculous lung lesions were present, but aspiration of the pericardium for relief of tamponade



FIG 266—Evolution of tuberculous constrictive pericarditis (Case 1). A, Enormous pericardial effusion producing cardiac tamponade after aspiration and gas replacement. The size of the heart is demonstrated and also thickness of pericardium. Note pulmonary infiltration in upper part of right mid-zone. B, Pericardium fully contracted round the heart. Note hardening of lesion in right lung. C, Kymograph taken some months after operation. Free excursion of left heart border, with almost complete fixity on the right.

is highly doubtful that the constriction could ever produce such a degree of stenosis that a direct surgical attack on this region should be necessary. Fibrosed extrapericardial adhesions to pleura and precordium are constant, but unimportant, associates of the constrictive process.

on no occasion revealed tubercle bacilli. It should be remembered that a membrane covered by active and ulcerative tuberculous tissue may produce an effusion which does not reveal bacilli, even after careful examination by culture and guinea-pig inoculation.

With a chronic effusion the pressure of which is unrelieved the signs of tamponade become indistinguishable from those of early constriction (Fig 266). The veins of the head and neck and upper extremities become engorged, the liver enlarged, and ascites is present. These signs persist and become accentuated as constriction develops, and undoubtedly the circulatory disturbance has a definite adverse influence on the general condition of the children. Stunted growth, extreme emaciation (masked to some extent by ascites and oedema), coldness of the hands and feet, and a general picture of apathy and lassitude predominate. The fingers

Under control there is little risk of harm during any period of observation. The heart muscle will not suffer from the constricting effects so long as it is not subjected to further strain, and effusions can be relieved by aspiration, and re-accumulation retarded by low fluid intake and the use of mercurial and other diuretics. Prolonged rest is, in our view, imperative in children and youths, where there exists a possibility that the causative process has not been stabilized. The likelihood of tuberculosis as a aetiological factor makes it equally important that active disease should be given adequate chance to heal. In one example in the present series a tuberculous peritonitis and spine developed during observation, and another died of miliary tuberculosis. The relationship of constrictive pericarditis with polyorrhomenitis (polyserositis) is probably more intimate than commonly supposed. A connexion is recognized, but the multiple serous effusions are often regarded as being *post hoc*, whereas their presence may precede constriction. Effusions as a possible part of a generalized tuberculous process may herald pericardial fibrosis, and as constriction develops the serous effusions persist and even increase—the raised venous pressure producing a transudate the volume of which is added to the original inflammatory exudate.

## ROLE OF SURGERY

Removal of the restraining pericardium to allow as full a ventricular expansion as possible is the only treatment for established pericardial constriction. Excision of all the pathological pericardial tissues would be the ideal, this is not practicable, but the improvement following a limited removal is remarkable. Excision should aim primarily (and possibly only) at freeing the ventricles, though for anatomical reasons even this is rarely achieved. The usual procedure is to resect the anteriorly placed pericardium and to carry the dissection outwards over the apex and round the left border of the heart. The very thinness of the auricles and great veins makes interference over them a hazardous undertaking (Figs 269, 270). Attempts to perform an extensive ventricular clearance without opening into the left pleural sac often results in a more limited operation being performed than was originally planned. To free the left border of the heart to an adequate extent the dissection should be carried posteriorly beyond the line of the phrenic nerve but to do this and at the same time to preserve the integrity of the pleural cavity is practically impossible. Consequently a deliberate trans-pleural approach to the heart may be countenanced as readily as the more popular extrapleural exposure. Where the signs are not too severe the probability is that a very limited operation may be performed with some definite relief of symptoms, and, on the whole, where difficulties arise it is better to limit the extent of the operation and remain within the bounds of safety. This policy, however, needs some critical qualification from the point of view of the end-results, which tend to show that a more extensive removal of pericardial tissue would have been advisable. The incision through pericardium should be carried through both layers down to the heart muscle



Fig 267—Appearance of child twelve months after pericardial excision. Even in absence of ascites note enlarged belly and general shape of the trunk (Case 1). Incision scar touched up by dotted line.

occasionally show clubbing, nails and hair are of poor quality and brittle, and the intellectual development is generally retarded. The shape of the body produced by the enlarged belly has already been mentioned (Fig 267).

The future of a patient with constrictive pericarditis depends on the rate of development of the condition. The slowly developing case which is not submitted to careful and systematic investigation may pass through many hands before the disease is finally diagnosed. These patients can live for years in limited and tolerable health, as was evidenced by Nils Finsen (1904), who, having fallen ill at the age of 23, developed the classical signs, and though incapacitated survived 21 years, during which period he received a Nobel Prize for his work. But this is exceptional, few survive to old age, and the case is a very strong indication for operation, which is even more urgent with quickly developing lesions. A slower course makes diagnosis more difficult, and the indications for surgery not apparently so imperative.

and not only through the parietal layer (*Fig 268*) This must be emphasized, because it is quite easy to find a plane of cleavage between the parietal and visceral pericardium even after years of apparent adherence The dissection plane between visceral

section of this region (*Fig 270*) that there is little margin for error

The tolerance of the heart muscle to handling is considerable The ventricles respond to manipulation by repeated extrasystoles and are liable to fibrillate if touched too often and too much, consequently periods of rest should be a routine part of the operation During these intervals small warm packs or muscle-grafts can be applied to bleeding areas on the freed heart muscle The possibility of cardiac arrest is present, but with the heart practically under manual control this need not be too alarming, 5 c.c. of 1 per cent procaine injected intravenously is said to be of value in controlling an unduly turbulent heart

One of the most dramatic aspects of operation is the way in which the heart may leap to freedom as its casing is peeled away The freed muscle bulges out of the excised area (adding to the difficulties of dissection) and will sometimes stand from 1 in to 1½ in away from its original bed (*Fig 271*) Undoubtedly though the muscle may be normal the sudden release is associated with some over-stretching, since

there is exaggerated pulsation and a greatly increased bulk of the heart Thus, however, usually quiets down within a week of the operation It may be that some of the post-operative deaths are due to this dilatation with fibrillation, and it might be wise to stage the operation if the access to freedom is too violent and looks like being uncontrolled

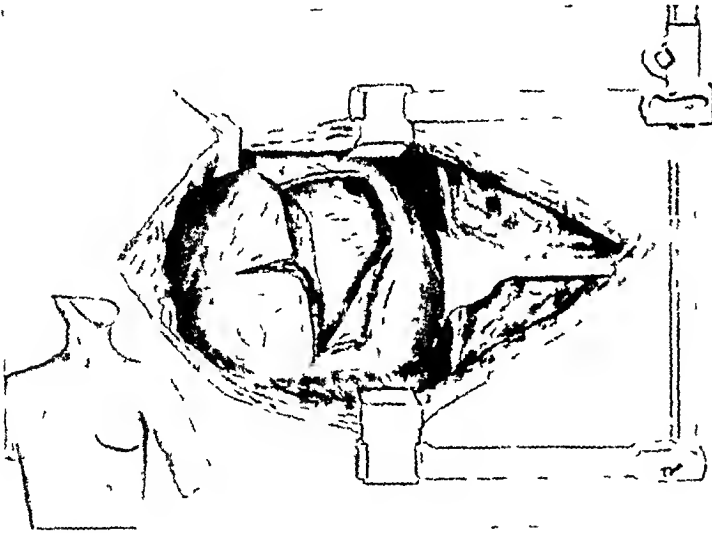


FIG 268—Appearances in the initial stages of pericardial resection (*Case 5*)

pericardium and myocardium is nothing like as easy to define (*see Fig 270*)

The most convenient site for starting excision is over the anterior part of the right ventricle, but the dissection should soon be carried over to the left ventricular region, so that the sudden release of the right heart does not lead to overloading of the pulmonary vascular bed until the stroke of the left heart is ready to receive it The interventricular junction is marked by the slightly tortuous course of the descending branch of the left coronary artery—a vessel that on no account must suffer damage Undue firmness of the constricting scar at this point may make it advisable to stop dissection and start again beyond the vessel, thus leaving a narrow strip of pericardium attached along its course Once the correct plane has been reached a flap of pericardium can usually be raised by blunt dissection, though irregularities in thickness or structure (e.g., a calcified plaque) may necessitate a change of direction until the area can be more clearly defined The use of a knife or scissors can be considered where undue adherence occurs Flaps of pericardium should be kept intact until the completion of the dissection, when they can be cut away, they act as retractors and are available for closure of rents or tears in the heart muscle should this misfortune arise At no time is it wise to carry dissection beyond the range of vision or unimpeded access

The full aim of dissection is to free the anterior surface of the right ventricle and the front part of its diaphragmatic aspect, and to free the left border of the heart down over the apex well on to the diaphragm and to complete excision laterally behind the level of the left phrenic nerve (*Fig 269*) The obliquely placed auriculo-ventricular groove marks the upper limit, and though clearance beyond this area is frequently advocated it can be seen from a



FIG 269—Post mortem appearances of heart after pericardiectomy to show extent of dissection Edges of excised tissue are indicated by arrows (*Case 3*)

A few cases do not show this operative exuberance, the muscle is easily dented and the heart remains the same size This does not necessarily imply wrong selection of the type of case suitable for surgery, but is more likely to indicate that the constrictive process has not fully developed in other words the condition is one of constricting rather than constricted pericarditis (*Case 4*)

**Indications and Preparation**—Direct attack on the heart surface cannot be entertained lightly. Most careful assessment of the case and correct timing are essential so that the circulation is relieved of as much strain as possible. The diagnosis may even be in doubt and then a considered exposure of the heart is fully justified to demonstrate the state of the pericardium and to proceed if required. Subject to the ability of the patient to withstand

adequate oxygenation can be provided. The anaesthetist must be prepared to deal with an open pleural cavity and may require tracheal intubation, though controlled respiration is hardly necessary. Chloroform and trilene are usually excluded on the grounds of toxicity, and gas-oxygen alone does not allow a high enough oxygen concentration. Local anaesthesia has its supporters, but it is not satisfactory if the pleural cavity is opened, and if used

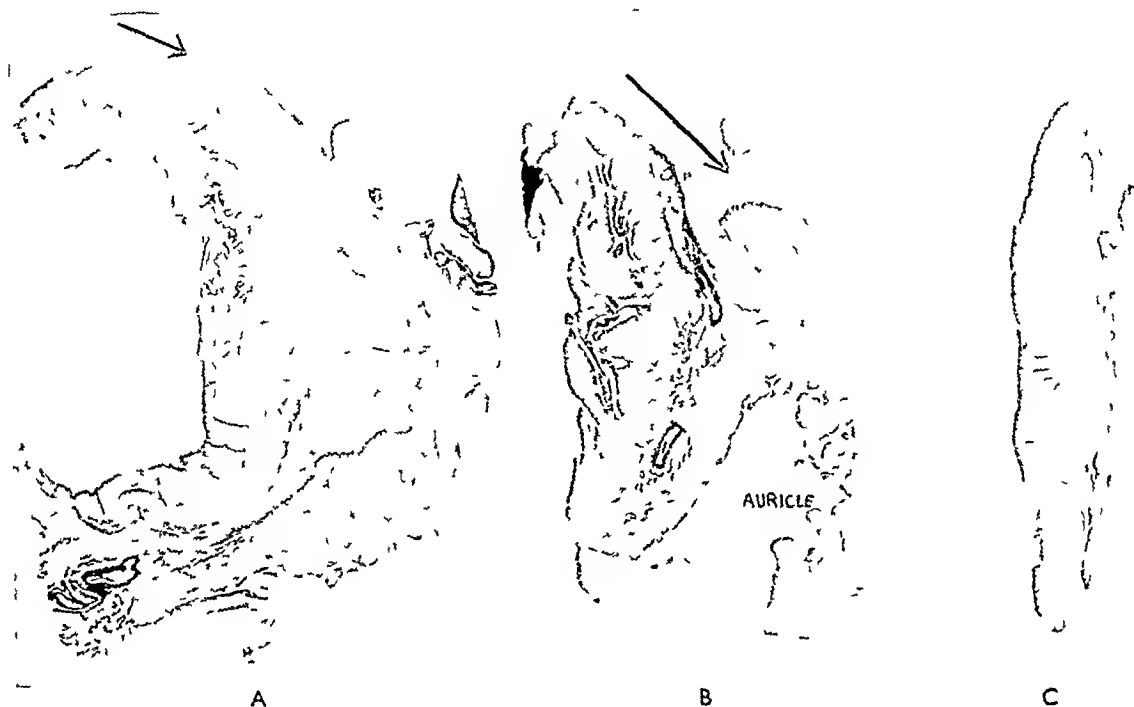


FIG. 270.—Sections through heart after pericardiectomy (Case 3). A, Posterior diaphragmatic surface of heart. Arrow indicates cut edge of pericardium. Note firm attachment of heart muscle, pericardium and diaphragm to each other. B, Auriculo-ventricular groove. Ventricle has been freed. Note thinness of auricle wall and the difficulty that would be encountered if pericardium were to be excised from this area. C, Excised pericardium. Lamination indicated the plane of fusion between parietal and visceral pericardium.

the operation, every case of true constrictive pericarditis is eligible for surgical consideration. Conservative measures, no matter how careful and prolonged, can only be palliative.

If, as we believe, tuberculosis is the most potent causative agent, all precautions must be taken to see that the disease is reasonably stabilized before operation. Too little attention is sometimes paid to radiographic evidence in the chest and elsewhere.

Preparation for surgery consists of rest for a reasonable period and relief of the pressure of serous effusions. Paracenteses will be required and the volume of the effusions can be controlled to some extent by limiting the fluid intake and maintaining high output with mercurial diuretics. The use of mersalyl over long periods has not been associated with ill effect. Preclusion of fluid into the serous spaces also demands a low salt intake, and if the plasma proteins are low a high protein content diet is indicated. The use of quinidine, if the heart is unduly irritable, has been advised, but there is no place for digitalis therapy.

**Anaesthesia.**—The choice of anaesthetic agent is largely an individual problem, subject to the proviso that the agent used is not toxic and that

at all should be confined to the exposure stages. In the present series Dr Parry Brown has used reduced premedication followed by gas-oxygen-ether or cyclopropane throughout the operation. The alleged irritant effect of cyclopropane has not been found significant and there were no untoward occurrences during the operations. In all cases the patient was flat on the table, no particular benefit was derived from raising the patient's head.

Blood transfusion is not indicated, but we have had blood available in case of any sudden or unexpected haemorrhage. The congested veins have the advantage of being readily accessible should intravenous therapy be required.

**Exposure**—The heart can be reached in two ways, one aiming at exposure without entering the pleural cavities, the other working deliberately across the left pleural cavity.

The extrapleural approach can be made through an incision which starts along the line of the 2nd or 3rd left costal cartilage and extends down the midline to end along the line of the 6th left cartilage. The skin-flap and underlying muscle are reflected outwards, and the 3rd, 4th, 5th, and possibly 6th costal cartilages are resected with a small piece of

the adjacent ribs. The exposed internal mammary vessels, if not already injured, are ligated at the top and bottom of the wound and the left pleural sac which lies under most of the exposure is reflected away from the midline by blunt dissection. A moderate degree of firm adhesion is to be expected. The heart lies more deeply than might be supposed and further exposure may be gained by punching away pieces of the left sternal border (*Fig 271*)



FIG 271—Appearance of the heart at the completion of pericardial resection. Note how the heart has enlarged from its diaphragmatic bed (*Case 2*)

The transpleural exposure is achieved by a sub-mammary incision along the 4th left interspace through muscle down to the rib level. Close to the sternum the costal cartilage above and/or below the selected interspace is divided and after securing the internal mammary vessels the pleural cavity is entered. The opening between the ribs is enlarged by use of a rib-spreader and any adhesions of lung to chest wall or anterior mediastinum are separated (*see Fig 268*). This approach allows more direct attention to be paid to the left border of the heart, but is not so effective for the anterior surface. In both cases the right side of the heart is not really accessible, and on the rare occasions that this is required a modified exposure will be required.

The heart and pericardium usually present as a more or less solid looking mass, deeper than anticipated and with a limited degree of pulsation. The method of dealing with the actual pericardium has already been indicated, as far as this difficult part of the operation can be discussed in print. On completion of the operation the incision is closed in layers after evacuation of air and fluid from the pleural cavity if this has been opened. Drainage is

not necessary, though aspiration of the pleural or extrapleural cavities is required until the spaces are dry.

**Complications and Dangers**—Cardiac arrest and hæmorrhage are the outstanding dangers during operation. The heart is surprisingly tolerant of gentle manipulation, though if extrasystoles occur too frequently the heart should be rested for a minute or so, it is continued handling in the face of irregularities that may cause arrest. Even then it is possible to regain the heart beat by a period of rest with careful manual or electrical stimulation of the ventricular muscle. Hæmorrhage from the myocardial surface usually stops spontaneously, but if persistent may require a warm pack or free muscle-graft. Damage to a coronary vessel is best remedied by suture of a muscle-graft over the bleeding point in preference to application of sutures which may further injure the blood-supply to the myocardium. Gross hæmorrhage is generally the result of opening into one of the heart chambers. The auricle regions are most obvious points of danger, and the wall of the right ventricle is more liable to penetration than the left. Missing the plane of dissection and tearing into heart muscle is where misadventure is most likely to occur, and burrowing plaques of calcium give their own warning. Experience suggests that it is advisable to stop operation if any untoward occurrence is encountered, this is not irretrievable, since the plane of dissection is comparatively easily recovered at a later operation and is not unduly obscured.

Cardiac dilatation and ventricular fibrillation are later dangers to which allusion has been made. Early and complete re-expansion of lung is essential if the pleural cavity has been opened, since a collapsed lung will add to the circulatory load. The dangers of activation of a tuberculous process cannot be ignored, though careful selection and timing of the operation should reduce this complication to a minimum.

The post-operative period is usually uneventful, though the most careful watch for any untoward signs and symptoms must be made. Oxygen is sometimes required, and the continuation of the pre-operative medical treatment in the form of restricted fluid intake and mercurial diuretics should be practised. Recovery may be rapid in the early stages, but there is often a definite lag period over the first two weeks before active improvement sets in. Good symptomatic progress can usually be noted, though the signs are much slower in regression. Where complete recovery occurs the case is probably of relatively short duration, the possibility of liver and visceral damage hindering complete recovery in older and more long-standing cases should be considered.

**Effects of Pericardiectomy**—Though an efficient freeing of the ventricles actually restores the pulse pressure to an almost normal level at the time of operation, the venous side of the circulation responds much more slowly. A lowering of the venous pressure and reduction of ascites and liver size may be noted within a few weeks, but full and final improvement should not be expected within twelve to eighteen months. It may be that, though ventricular function is restored and an increased

output from the heart thereby attained, the co-ordinated contraction and elastic recoil of the auricles are not reinstated at the same time and are more slowly compensated.

Rapid amelioration of symptoms is usual, quite out of proportion to decrease in the signs, and the improvement is maintained in practically all cases. The venous pressure, however, often persists at a high level without causing the patient much inconvenience. Functional recovery can be of the order that permits a totally incapacitated patient to return to active physical work sometimes of heavy character, but commonly the duration of the illness has made its mark and the patient though relieved of symptoms is content to, and probably only capable of, leading a quiet existence. The question of interference with liver function has already been mentioned as a possible cause of failure to realize full recovery. Inadequate surgery is the most obvious reason for an imperfect result, great clinical improvement can often result from an apparently minimal clearance of pericardium, but the term 'cure' can critically only be applied to those cases in which the pericardiectomy has been extensive.

Recurrence of the scarring as a possible late sequel should not be excluded, but the type of scar which forms over the excised area is of loose vascular form and is most unlikely to constitute a dense fibrous membrane again.

**Figures and Results**—The collected figures for pericardiectomy are sufficient for a preliminary assay of the value of the procedure, but certain factors must be borne in mind when they are reviewed. Of the total 143 cases recorded by Heuer and Stewart (1939) there were only 8 surgeons (7 only checked) who had published a series of more than 5 cases, 27 of the protocols were single efforts and doubtless a great many failures have not been recorded. The results published give an average of over 50 per cent cured or improved, the operative mortality lying in the region of 33 per cent, with about 10 per cent later deaths. Individual series such as those of Blalock (1940), Tudor Edwards, Churchill, and Heuer, as might be expected, give better results, and it is along the lines of considerable experience rather than on individual attempts that the success of the operation will be judged. An assessment of the current literature to which have been added some figures personally contributed by surgeons in this country, including a series of 18 from Tudor Edwards, brings the total up to 227, with a tendency towards reduction of the death-rate and consequent improvement in the final results.

## CASE REPORTS

**Case 1**—Female, aged 11 years. As a baby the patient suffered from rickets and was in bed for four years. She then remained normal until 10 years old, when pain in the legs developed. Later the child complained of shortness of breath and had to sleep propped up, swelling of the abdomen was also noted.

**ON EXAMINATION**—The child was weakly and under-sized. Marked cyanosis was present with dyspnoea and cough on the least exertion. Venous engorgement in the neck and face was well defined, with pulsation considerably raised. Prominent veins were also present over the chest. The area of cardiac dullness extended

into the posterior axillary line and 4 cm. to the right of the midline with no pulsation and inaudible heart sounds. BP 86/66. Pulse paradoxical, rate 100. The liver was enlarged 4 cm. below right costal margin, there was no ascites or oedema of the legs. Radiologically the huge globular outline of the heart was noted with complete absence of pulsation and some congestion of the lungs. There was a small area of pulmonary infiltration in the right mid-zone.

The diagnosis of chronic tamponade, due to pericardial effusion, was confirmed by aspiration of 30 oz. of straw-coloured fluid (see Fig 266, A). Re-accumulation of fluid was rapid and a further three aspirations, with total removal of over 4½ pints, were performed during the next eight weeks. The fluid was cultured for tubercle bacilli, with negative results, the cellular content showed 99 per cent lymphocytes.

Electrocardiography showed inversion of the T-wave in all leads. Patch test positive for both bovine and human T<sub>2</sub> in blood chemistry.

Rapid fluid, with a tendency to tamponade, suggested that a more permanent method of relief other than by aspiration might be attempted—namely, that a pleuropericardial fistula might be made to allow the larger serous surface of the pleural cavity to share in absorption.

**OPERATION** (April 23, 1942)—Incision along 4th left interspace anteriorly, with division of 4th costal cartilage. Free pleural sac opened, pericardium massive and immobile. The pericardium was a massive covering to the heart and on incision was over 1 cm. thick. The condition was that of a 'bread and butter' pericarditis with fluid and softening areas between parietal and visceral layers. The parietal area was freely excised over the left border, apex, and diaphragmatic surfaces, but efforts to identify the plane between visceral pericardium and heart muscle were abandoned after several efforts. The heart remained 'silent' with very poor pulsation and no tendency to enlarge. Closure without drainage was effected.

**PATHOLOGY**—The excised tissue showed an active tuberculous process with fibrin in the process of organization, scattered tubercles, granulation tissue, and Langhan's giant cells, occasionally of very large size.

**PROGRESS**—There were no ill effects from interference and clinical improvement was satisfactory. It was, however, realized that failure to remove the complete thickness of the pericardium might necessitate a further operation. Six months later there was still some raised venous pressure and an enlarged liver.

A year after operation venous pulsation was 60 mm. above the level of the auricle. The liver and belly were still enlarged, but cyanosis was absent and the child's intelligence and growth were satisfactory (see Fig 267).

Two years after operation the condition was still improving. The raised venous pressure was barely noticeable, cardiac pulsation was vigorous, and though the liver was still large there were few physical limitations. She could climb 45 stairs without becoming dyspnoeic. Kymography showed free movement of the left heart border (maximum lateral movement 2 cm.) but complete immobility on the right (see Fig 266, C). Three and a half years after operation the patient developed a large cold abscess in the thigh, suggesting that the tuberculous process was still active.

**Comment**—In this example of tuberculous pericarditis the effusion originally led to gross tamponade, but the process of constriction was not suspected until the time of operation. The effusion was followed by a very rapid cicatrization of the pericardium, and though the tuberculous nature of the condition was suspected, it could not be proved, until the excised pericardium was examined.

**Case 2**—Male, aged 43 years. In 1929 the patient suffered from pneumonia followed by a right empyema



requiring drainage. Oedema of the legs developed shortly after this.

The swelling of the legs extended and became brawny in character, and nine years later constrictive pericarditis was diagnosed. Oedema of the legs became worse and ascites developed, but the patient was able to do a certain amount of work.

By 1942 there was definite dyspnoea on exertion, with slight cyanosis. The man was heavily built and in reasonable general condition. Venous congestion was noted, with pulsation 60 mm above the auricle level. There was slight oedema of the hands and forearms. Massive brawny oedema of the legs and thighs was present. The heart was not enlarged and the apex-beat could not be detected. There were bilateral basal rales in the chest. The abdomen was grossly enlarged by ascites and the liver was just palpable.

The right diaphragm was high with basal pleural thickening and possible bronchiectasis at the right base,

Suture without drainage. Several periods of rest were required during operation to allow irregular rhythm of the heart to become steady.

The excised tissues showed only extreme fibrosis with heavy collagen fibres (see Fig 265, B).

**PROGRESS**—Convalescence was satisfactory and the exaggerated pulsation of the heart subsided within 3 weeks. Paracentesis was continued and mersalyl used in conjunction with a limited fluid intake. The output to intake ratio at one period was 6 to 1. On discharge the leg oedema had largely disappeared, though brawny thickening persisted. Liver was not palpable and there was only a trace of ascites. Venous pulsation in the neck was 3 cm above the angle of Louis. B.P. 102/80. Loss of weight since admission, 4 st. Vital capacity, 1800 c.c.

Later progress was satisfactory, the patient returning to full work in comfort. Auricular flutter developed without subjective symptoms, and has been observed



A



B

FIG. 272.—Radiographic appearances during the development of constrictive pericarditis (Case 3). A. Large pericardial effusion. B. Constriction fully developed 18 to 21 months from onset. Heart shadow is obviously smaller. Ascites controlled by paracentesis. Effusions have disappeared.

the heart shadow showed almost complete immobility. B.P. 100/60. Marked pulsus paradoxus. Vital capacity 1100 c.c. Electrocardiography showed moderate voltage. P-R interval 0.2 sec, QRS 0.08 sec. T-wave positive. Sinus arrhythmia. Markedly bifid P-waves in all leads.

Ascitic fluid was pseudochylous, with a fat content between 10 and 60 mg per cent, proteins 0.5 to 0.7 g per cent, lymphocytes 86 per cent. Sterile to culture, including T.B.

Abdominal paracentesis was repeated on several occasions (total 24 pints), and a serum transfusion of over a litre was given. Mersalyl injections were started.

**Pericardiectomy** (April 16, 1942).—Exposure of pericardium after removal of 3rd, 4th, and 5th costal cartilages and part of adjoining sternum. The heart was deeply placed, completely immobile, and stone-like. The covering was firm and whitish, without any calcifications. Incision was followed by rapid and extreme herniation of the heart muscle. The pericardium was  $\frac{1}{8}$  in thick and remarkably tough, it was cleared over the anterior surface of the ventricles, apex, lateral border, and part of the diaphragmatic aspect of the myocardium was freed, (Fig 271). The enlargement of the heart was extreme and the ventricles stood out beyond the level of the skin surface. The pleural cavities were not opened

intermittently. No signs of raised venous pressure now remain, though there is some thickening of the legs.

**Comment**—This case of fully developed constriction resulted probably from a suppurative pericarditis following an empyema. Ascites was predominant and the released heart quickly restored this condition. The appearance of auricular flutter after operation should be noted.

**Case 3**—Male, aged 11 years. At the age of 8 pain in the left chest, suggestive of pleurisy, preceded signs of pericardial effusion, associated with fever up to 102° F, lasting 5 weeks. Marked tachycardia was present. Pericardial fluid was aspirated. It was sterile and with protein content of 2.5 g.

The child was wasted with a large belly, thin hair, and cold blue extremities. There was dyspnoea on exertion, cyanosis, and slight cough. Veins in the face and neck were congested with venous pulsation more than 10 cm above the auricle level. The heart apex-beat was impalpable and the sounds barely heard. Pulse 100. B.P. 110 mm Hg. Pericardial effusion had absorbed and the heart outline was normal in size. There were signs of a right pleural effusion from which fluid was aspirated (sterile and clear). The abdomen was distended with gross ascites and the liver was palpable. There was oedema of the legs.



Radiologically the heart was of normal size, with very diminished pulsation on all borders. A small opacity in the right mid-zone was suggestive of tuberculous infiltration. Patch test was negative and serous fluids and sputum were negative on culture for tubercle bacilli. BSR 2 mm/hour. Circulation time 22 sec. Hb, 102 per cent. Plasma proteins 5 g per cent (A/G ratio 1.5/1 per cent). Ascitic fluid had a protein content of 0.59 g per cent, chlorides 700 mg per cent.

During a period of observation which lasted over a year and a half from the time the pericardial fluid had absorbed, a left-sided pleural effusion developed. Bed rest and mersalyl injections with frequent abdominal paracentesis produced some improvement, but the venous pressure remained constantly raised.

**Pericardiectomy** (Jan 13, 1944).—Exposure of pericardium by removal of 4th, 5th, and 6th left costal cartilages with opening of the pleural cavity. A moderately thick pericardium (4 mm) was removed from an immobile

of breath and some swelling of the ankles. This was progressive and the oedema extended up the thighs to the scrotum.

**ON EXAMINATION**—The youth was large and well built. Engorgement of the neck veins was obvious, with visible venous pulsation above the angle of the jaw. The heart apex-beat, though not strong, was audible and in normal position. There was some ascites and the liver was enlarged 5 cm below the costal margin. Oedema of the lower extremities rapidly subsided in bed.

Radiology showed a broad upper mediastinum with some congestive markings in the lung fields. On screening the heart pulsation was greatly diminished—a feature confirmed by kymography (Fig 274, A). Vital capacity was 1900 cc. Electrocardiography showed inverted T-waves and general low-voltage waves. Blood haemoglobin 98 per cent, white cells 15,000, plasma proteins 5.59 g per cent. Circulation time 22 sec. No evidence of any tuberculous lesion.

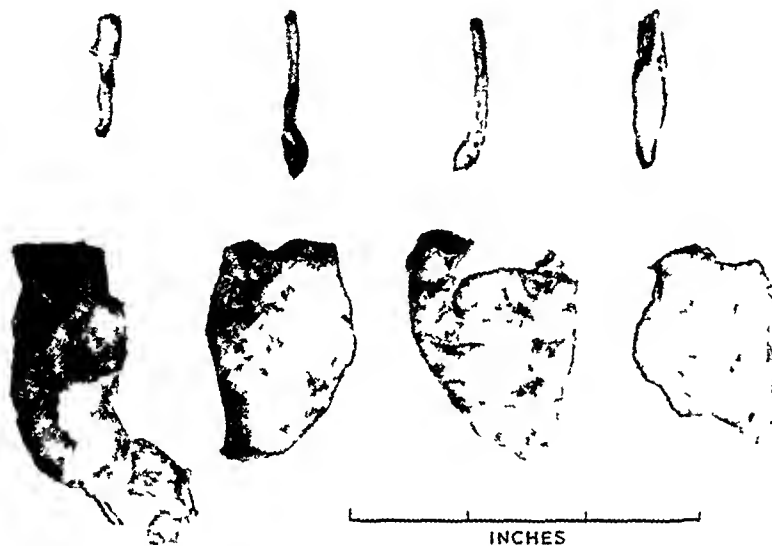


FIG 273—Tissue excised at operation of pericardiectomy

heart off the anterior, lateral, and inferior aspects of the ventricle (Fig 273). Freeing of the heart displaced the apex  $\frac{1}{2}$  in. to the left of its constrictive bed. Condition at the end of the operation was satisfactory.

**PROGRESS**—A good recovery followed with a full regular pulse, but suddenly 18 hours later he collapsed and died in 15 minutes. No reason could be advanced beyond an attack of ventricular fibrillation.

Post-mortem examination showed a friable but otherwise normal myocardium. The lungs showed marked brown induration. The abdominal peritoneum was thickened greatly and the liver was enlarged, showing 'nutmeg' changes (see Fig 269).

Microscopy of the pericardial tissue adjacent to the excision showed tuberculous systems amid areas of great fibrosis (Fig 274, A).

**Comment**—This case of polyserositis accompanied by constrictive pericarditis was stabilized over a prolonged period to allow the active tuberculous process to become quiescent. No apparent harm was done by conservative treatment and operation was, at the time, well tolerated. The sudden collapse and death probably from ventricular fibrillation was entirely unexpected.

**Case 4**—Male, aged 18 years. Accepted A1 for the Services, but within a month complained of shortness

of breath and some swelling of the ankles. This was progressive and the oedema extended up the thighs to the scrotum. Mersalyl injections were started.

**Pericardiectomy** (Dec 16, 1943).—Exposure obtained by removal of 3rd, 4th, and 5th costal cartilages, with piece of adjacent rib. The pericardium was whitish, thickened, and immobile. It was incised anteriorly down to heart muscle and dissection of the flaps formed carried to the left border of the heart where the adherent pleura was opened. The pericardium was fibrous and uniformly thick (3–4 mm). Clearance was made behind the level of the left phrenic nerve, which was dissected free, round the base of the heart off the diaphragmatic attachment, and anteriorly off the ventricles. The heart was irritable during manipulation and did not show any tendency to bulge during the freeing process. It gave the impression of being soft and not restrained.

Microscopy revealed many tuberculous giant-cell systems with epithelioid cells and abundant fibrosis.

**PROGRESS**—Convalescence was satisfactory and rapid improvement resulted (Fig 274, B). Within eight months full capacity for exercise and work was achieved with a normal venous pressure.

**Comment**—Though the tuberculous nature of this case was not revealed until after operation, it was accompanied by no ill effect. Clinically the diagnosis was

made in the earliest stages and operations carried out in the constricting phase, rather than after full constriction had developed

**Case 5**—Male, aged 48 years Occupation, chauffeur History of "influenzal" illness of severe character in childhood Present disability started two or three years ago with increasing shortness of breath and palpitations Recent more severe symptoms included tenderness over liver and exhaustion with increasing breathlessness Slight jaundice on occasions within the last 10–15 years had been noted

**ON EXAMINATION**—General condition was reasonably good, though the man was thin and pale Cyanosis of the upper extremities, head, and neck was noticeable and exaggerated on lying flat The veins in these parts were engorged with visible pulsation well above normal limits Venous pressure by direct measurement was

Pericardium was incised and dissected off the heart muscle, not without considerable oozing It was of variable thickness and the parietal and visceral layers could be separated, so that care had to be taken not to leave the visceral membrane intact on the heart Dissection was carried round the lateral wall of the left ventricle to the line of the phrenic nerve, over the apex and well on the diaphragm and anteriorly as high as the auriculo-ventricular groove No burrowing plaques of calcium were encountered over this operation area The freed heart pulsed powerfully, but the muscle did not bulge unduly

Pathological examination of the excised pericardium showed fibrous tissue with polymorph emigration from vessels and some fibrin on the surface No evidence of tuberculosis

**PROGRESS**—Convalescence was not completely smooth, with bronchitis and multiple extrasystoles as the main

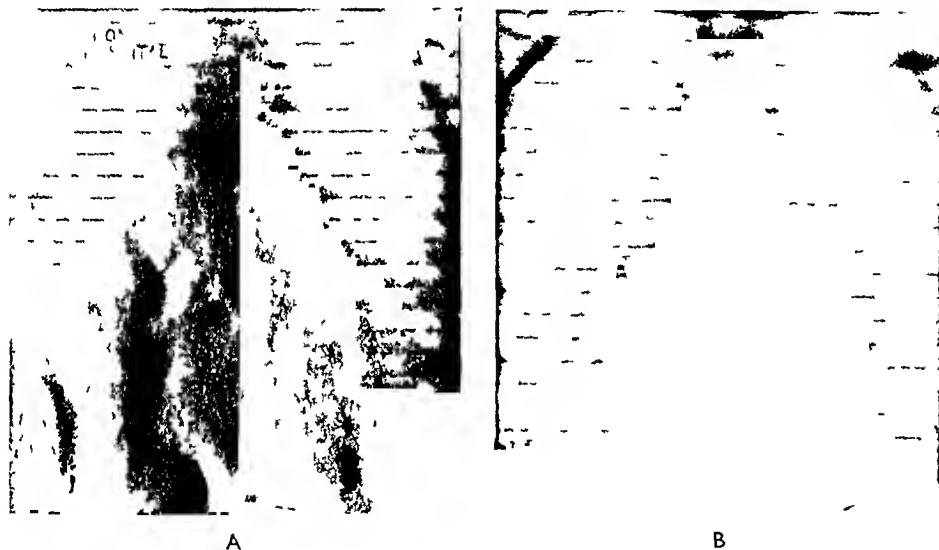


FIG. 274—Radiographic appearances before and after pericardial resection (Case 4) A, Pre-operative kymograph Pulsation almost completely absent over the whole heart B, Post-operative kymograph Reasonable pulsation of the left heart border, slight movement only on the right

180 mm The heart apex-beat was visible 4 in from the midline in the 5th space Sounds were audible here and the 2nd sound was reduplicated Pulse-rate 60, frequent extrasystoles BP 120/74 Liver was enlarged two finger-breadths below the costal margin and was tender Epigastric veins were unduly prominent (with blood flowing upwards) Evidence of ascites was doubtful

X-ray examination showed increase in the transverse diameter of the heart with calcification of the pericardium, mainly on the right ventricle and left auricle (see Fig 263) Bilateral pleural thickening was present On screening cardiac pulsation was grossly diminished Vital capacity 2750 c.c Normal blood-count and chemistry Circulation time (saccharin, arm to tongue) 20 sec Electrocardiogram showed right axis deviation with negative T wave in Lead III only No suggestion of tuberculosis

There was some improvement on bed rest, though signs did not alter

**Pericardiectomy** (Dec 7, 1944)—Exposure made by dividing the 4th costal cartilage and entering the left pleural cavity along a 4-in interspace incision (see Fig 268) The lung was adherent to pericardium which showed little if any pulsation Plaques of calcium were palpable in the pericardium, though not noticeable in the ventricle walls Their main distribution was in the auriculo-ventricular grooves and over the auricles and great veins

complications Within two and a half weeks recovery was satisfactory

Ten weeks after operation all symptoms had disappeared Venous pressure 100 mm water BP 150/98 Vital capacity 2900 c.c Forceful impulse of heart with normal sounds Four months later he returned to full work

**Comment**—Though on the evidence of marked calcification this case was of long-standing duration, the actual constricting process was of limited duration and was treated before it became too gross

A further 12 cases of constrictive pericarditis have been observed, but have not been submitted to surgery Seven of these (6 of tuberculous origin) await surgical interference, 1 refused operation, and 2 died, 1 of generalized tuberculosis and the other was in too advanced a condition to consider operation

In addition 4 autopsy specimens were studied The cause of death in three instances was almost certainly constrictive pericarditis, unsuspected during life In the fourth instance an associated cardiac condition of congenital type was responsible for death

**Acknowledgement**—Many of my colleagues have contributed largely to the investigation, study, and care of the patients concerned. To them and their assistants my warm thanks are due. By name I would particularly like to mention Professor G W Pickering, who has been unfailing with his advice and experience. In the realm of radiology Drs L G Blair and Franklin Wood have given every assistance, and Dr M Pryce has been untiring in pathological investigation. My thanks are also due to Dr Pagel for providing many specimens of great value. Messrs A W Holder and W P Pereira have produced nearly all the illustrations and specimens for this article, while Miss Arnott kindly contributed the half-tone drawing.

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## THE LAST 'HATE'

### AN ACCOUNT OF THE ABDOMINAL INJURIES OF THE V-1 AND V-2 PHASES OF THE WAR ON BRITAIN AND OF THE SHELLING OF DOVER

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DURING the recent war the courtesy of the columns of the BRITISH JOURNAL OF SURGERY has been graciously extended to me on many occasions, and in two numbers a very generous page allowance was vouchsafed for my Bradshaw Lecture of 1942 and a Hunterian Lecture in 1944, both of which dealt with the abdominal injuries of 'total war', more especially those received by civilians during enemy air-attacks on this country, the abdominal injuries inflicted in naval warfare also came under consideration as well as many of the belly wounds incurred by troops in training that found admission to E M S Hospitals throughout the land. This communication constitutes a final chapter in that story. Of the abdominal injuries received by Army troops in battle I am unqualified to write this war, but the right of admiration cannot be denied me, and gladly I offer my laurel for tribute to those of another Service who have either guided or have performed the 'forward' abdominal surgery of this Armageddon in the lands of three continents and with a measure of success that has steadily waxed through the years of conflict and realized a percentage far exceeding the figures emanating from the first Great War more than a quarter of a century ago.

The following account of certain abdominal injuries received by men, women, and children in a special corner of Britain and produced for the most part by new mechanisms of Hun 'hate' which might be said to 'date' these casualties, perhaps has a historical rather than any profound surgical value. The cases have been collected partly through information tendered me by surgeons aware of my interest in the subject, partly by considerable personal endeavour involving frequent hospital-to-hospital visitation and inquiry. To those who have at all times so readily and gladly aided my efforts I am under an immense debt of obligation.

The total number of abdominal casualties resulting from the last indiscriminate attacks on

the south-east corner of England have fortunately not been numerous, and I have notes of only 120 patients submitted to operation. Of 79 cases of intraperitoneal visceral injury produced by V-1 bombs (the 'flying bomb') and submitted to laparotomy 60 patients recovered (76 per cent recovery-rate). Of 13 cases explored, where a hæmoperitoneum was found, but no visceral injury demonstrated, only 1 succumbed.

During the 'rocket-bomb' period 16 cases of intraperitoneal visceral injury were submitted to operation, of which only 9 recovered (56.2 per cent recovery-rate).

Of the 6 intraperitoneal visceral injuries received during the shelling of Dover and operated on, only 1 perished. The figures given here represent intraperitoneal visceral injuries for which operation was possible, cases of 'crush syndrome', retroperitoneal hæmatoma, and non-penetrating wounds of the abdominal wall are not computed.

### ABDOMINAL INJURIES DUE TO 'FLYING-BOMBS'

This essay does not purport to be a disquisition on the general characters of injuries produced by the 'flying-bomb', but there seems little doubt that injuries from V-1 bombs proved less severe than from the high-explosive bombs on Britain during the earlier years of the war. The damage to property during the V-1 phase was always greater than damage to people, and most of the casualties were secondary to blast effects on buildings, etc.

All have commented on the infrequency of intra-abdominal injury as the result of V-1 explosions, thus, G H McNab (1944) had only 3 cases of intraperitoneal injury in 187 patients treated for V-1 incidents in one hospital, and these were all moribund. R C Bell (1944) had no penetration of the abdomen in 259 patients in another institution, Miss M M C Loudon (1944) found less

than 1 per cent in over 800 injuries in a hospital in South London. Of the 79 patients in this series with visceral injury submitted to operation 14 had no wound and were suffering from damage inside the belly produced by blast, collapse of buildings, etc. The hideous ingravescant din of the 'buzz-bomb' streaking across the sky was a source of annoyance, threatening, like some three-headed Cerberus, burial, blast, or burn to those below, but it was splintered glass that inflicted many, if not most, of the wounds received during the V-menace. Opinions seem to differ as to the penetrating power of glass, but the evidence of cases collected for this review confirms the opinion recently expressed by Michael Smyth (1944), in our series of cases most of the abdominal viscera have been on occasion damaged by glass—intestine, liver, spleen, the left gastric artery, and the pregnant uterus, etc.

**Sex and Age**—Of the 92 cases submitted to laparotomy, 50 were females. There were 16 patients under 17 years of age, 8 of them under 10 years of age, and, in addition, there were 2 foetuses injured *in utero* that subsequently succumbed, 8 patients were over 65, of whom the eldest, with numerous wounds of the intestine, who died on the operating table, was aged 86. A woman, 'mine hostess' of a tavern, aged 66, recovered from a wound of the caecum (H. Nockold's case), and a man of 65 from a wound of the duodeno-jejunal flexure and several lacerations of the small gut and the meso-sigmoid (H. W. L. Molesworth). T. Meyrick Thomas and R. A. Kerr each saved the lives of two-year-old children, the former's patient had been buried under the debris of a collapsed house for three hours and had also a small wound over the left lower ribs in the mid-axillary line. The infant was found to have a wound of the stomach and edge of the liver, a small metallic foreign body, half an inch in diameter, was found embedded in the posterior abdominal wall just above the first part of the duodenum. In Kerr's infant the intra-abdominal damage was fortunately confined to the omentum.

#### Blast Injury—

**Case**—Evelyn R., aged 7, was thrown across a surface shelter by the detonation of a V-1 bomb, she was not thrown against any object which might have caused abdominal injury. There was no loss of consciousness, but there was abdominal pain within an hour, associated with vomiting. Over two pints of blood were found in the peritoneal cavity at laparotomy at Hackney Hospital, but no visceral damage was discernible. Recovery was uneventful (G. Neville Taylor's case).

A curious stroke of fortune directed at various times 5 cases of abdominal injury due to 'buzz-bombs' to the skilful hands of Meyrick Thomas, and 5 patients recovered. The case of the infant of 2 years has already been referred to, but two of his other successful cases were a girl of 9 and a boy 15 years of age. The last was apparently a blast injury of the abdomen—

**Case**—P. T., aged 15, was admitted to hospital in a very shocked condition one hour after a 'flying-bomb' had exploded on his home. He had hæmatemesis and hæmaturia and a considerable hæmoperitoneum was found on laparotomy. No visceral damage was demonstrable

except several contusions of the small intestine. No bruising of the anterior abdominal wall was present. The boy had also got a dislocation of the left hip-joint, which was reduced, and a fracture of the pelvis, a lacerated wound of the left calf was also present. A stormy convalescence followed operation, anuria was present for 48 hours, the blood-urea rising to 450 mg. Intravenous drip (blood, plasma, and saline) for 12 days. Ultimate excellent recovery (T. Meyrick Thomas's case).

The predilection of the 'flying-bomb' for children as its victims finds corroboration in those injuries which have involved the foetus *in utero*. One case of this kind where a foetus received a blast injury of the abdomen from a high-explosive bomb was recorded by the author in his Bradshaw Lecture in 1942. The 2 cases in this series were six- and seven-month pregnancies respectively.

**Case**—A woman was admitted to hospital after a V-1 incident with a wound of the right loin through which about half the length of the small gut had protruded and was lying in the patient's clothing. The degree of shock was only moderate, and it was possible to commence operation half-an-hour after the patient's admission, the usual resuscitation measures having been instituted. The wound in the loin, which was 4 in. in length, was excised and prolonged downwards and medially, the peritoneal cavity was full of blood and faecal matter, the caecum and terminal 2 in. of the ileum were severely lacerated. On passing his hand into the pelvis, the surgeon felt the legs of the foetus extruded through a rent on the right posterolateral aspect of the uterus. The foetus and placenta were quickly delivered through the uterine laceration, the damaged ileocaecal portion of the bowel was resected, the ends anastomosed, and the junction exteriorized. The ragged edges of the uterine laceration were excised and sutured. A piece of metal, 2 in. square, was recovered from the bottom of the pelvis, and another fragment half the size was so firmly driven into the tibia that a chisel had to be used for its extraction. 200,000 units of penicillin were administered, but death took place 56 hours after operation. Post-mortem the uterus was well contracted and the placental site was clean (F. W. M. Pratt's case).

**Case**—Doris R., aged 27, was seven months pregnant when she was involved in a 'doodle-bomb' incident in the South-east of London. She had multiple injuries due to glass, and one glass fragment had penetrated the abdomen and was removed from the cavity of the uterus, which contained a 7-months' child. Laparotomy was performed by Mr. J. L. Stephen, the child was extracted through the rent made by the missile. The mother made a good recovery, the child survived two days.

**Laceration of Inferior Vena Cava**—H. A. Kidd's successful suture of a laceration of the inferior vena cava has already been reported in the *BRITISH JOURNAL OF SURGERY* (1945).

**Proximity to Explosion of 'Flying-bomb'.**—A woman patient admitted to Charing Cross Hospital actually claimed that a 'flying-bomb' fell on her. She was profoundly shocked, and a deep wound of her right buttock was bleeding profusely. At operation by Mr. R. A. Fitzsimons the buttock wound was dealt with and found to involve the abdominal cavity. Laparotomy revealed the presence of a considerable amount of blood in the coelom, there was bruising of the lower sigmoid colon and mesosigmoid, and a tear 3 in. long on the left

antero-lateral aspect of the lower sigmoid involving the serous and muscular tunics. The condition of the patient rapidly deteriorated during the operation, which was therefore abruptly terminated. Next day the patient had improved, but equivocal abdominal signs and symptoms and the uncertainty as



FIG. 275.—Left kidney from patient with left sided abdomino-thoracic injury from fragment of metal from flying bomb. Recovery. (John Everidge's case)

to visceral damage engendered by the need of the hasty closure of the abdomen the preceding day compelled a fresh intervention. There was more blood in the peritoneal cavity, but despite the bruising and œdema of the lower sigmoid and pelvic rectum, the bowel was obviously viable. No other intra-abdominal lesion was found, and the woman ultimately made a good recovery.

**The Predilection of the 'Flying-bomb' for Hospitals**—The affinity of V-1 bombs for hospitals and institutions for the poor and aged equalled its predilection for babes and children. From one metropolitan hospital which endured more than its share of injury from indiscriminate air attack patients who had received abdominal injury were transported to London's most historic hospital, one had been an inmate of the damaged institution for severe heart disease, another had been tied to bed in a plaster carapace after an operation on her hip. One made a good recovery after a splenectomy (Harold Wilson), another under treatment in the first hospital for "a double aortic lesion and coronary insufficiency" was injured by glass in the right side of the belly. A wound in the right loin was found to penetrate the peritoneal cavity, but although there was an amount of blood in the cœlom, no visceral injury was discovered. He made a good recovery (Rupert Corbett's case).

A third case from the same damaged hospital had had an arthrodesis of the hip, and was admitted to St Bartholomew's in a severe state of shock and with a large wound in the left loin just below the left costal margin, half the spleen and fat were

protruding. It was only after twenty-four hours' efforts at resuscitation that any thought of operation was possible. As a forlorn hope the wound was explored, and a piece of glass 3 in / 2 in removed, which had gone through the lower three ribs, diaphragm, and pleura, completely bisecting the spleen. The patient failed to rally from the operation.

The British soldier in the London area did not escape scatheless in the matter of abdominal injury during the 'fly-bomb' period. Such a *rara avis* is reported below.

**Case**—An officer was injured in the open, and was admitted to hospital with a large jagged wound below the left 12th rib, and passing pure blood in the urine. X-ray examination revealed a large hemothorax with some mediastinal displacement and a large foreign body just below the left diaphragm. Aspiration of the chest was performed on two occasions, 35 oz and 32 oz of blood being removed. The wound in the loin was excised by Mr John Everidge, the left kidney was severely lacerated and contained a large metal fragment (Fig 275, Nat War Coll 397). There were two holes in the diaphragm, one probably caused by the fractured 12th rib, the other by the missile. Another two pints of blood were removed from the pleural cavity, and the diaphragm was repaired. The pleural cavity was intubated and water-seal drainage established. The lumbar wound was lightly frosted with flavine-sulpha powder, a few sutures were inserted, and also a vaseline gauze drain. The patient made an excellent recovery.

### ABDOMINAL INJURIES FROM ANTI-AIRCRAFT FIRE DURING V-1 PHASE

The wonderful achievements of the anti-aircraft gunners against the 'doodle-bombs' from across the Channel and North Sea have now been promulgated, but it would have been idle not to expect some casualties, even abdominal casualties, from "what comes down." Yet I have only notes of 3 abdominal cases during this period. Perhaps the most brilliant result in this type of casualty was obtained by Gerald Townsley, of Rochester, in a warden 68 years of age.

#### **Case—Abdominal-thoracic wound, fragment in right ventricle recovery**

Isaac M. was on duty when he was hit by a fragment of anti-aircraft shell. On admission to hospital two hours later he was profoundly shocked, of a cyanotic tint, and dyspnoeic. There was a penetrating wound in the epigastrium 1½ in below the ensiform cartilage, tenderness was present in the epigastrium, but there was no rigidity. Clinical examination revealed no abnormal pulmonary or pleural abnormality, the heart-sounds were faint. The radiographs were unsatisfactory, and no foreign body was visualized. After 3 pints of plasma had been administered, operation was performed eight hours after injury. After excising the wound in the epigastrium, the track of the missile was found to proceed upwards through cœlom, diaphragm, and pericardium, which was full of blood-clot. When the clot had been removed a laceration could be seen in the wall of the right ventricle which was oozing. On probing the aperture a fragment of metal was detected, this was removed, more free bleeding from the wound of the heart ensued, which was controlled by suture. The pericardium was not sutured, a piece of corrugated rubber drain was inserted through the wound in the abdominal wall down to the pericardium. The metal fragment measured 1½ in × ½ in. After operation,



auricular fibrillation continued for three days and then subsided. The man left hospital six weeks after injury, three months after discharge from hospital he was able to perform his ordinary duties, but became somewhat breathless on going up hills.

Another civilian anti-aircraft shell casualty was a right-sided abdomino-thoracic injury associated with a fragment in the wall of the second part of the duodenum. A successful result followed (H W Molesworth).



FIG 276—Rupture of spleen from collapse of house in close proximity to explosion of flying bomb. Recovery (H W L Molesworth's case)

### V-2 OR 'ROCKET-BOMBS'

The abdominal injuries received in this country from 'rocket-bombs' were few in number, careful and punctilious inquiry has failed to discover more than 16 abdominal visceral injuries due to V-2 incidents submitted to operation, almost half of these cases were due to crush injuries and associated with fracture of the pelvis and other bones.

Perhaps the first abdominal injury from a 'rocket-bomb' coming to surgery was successfully operated on by T Meyrick Thomas, whose record of success, apart from his Army service, in dealing with abdominal injuries received by citizens in this country is indeed an enviable one.

**Case**—A man was in a tree picking fruit when he was blown up into the air. On admission to hospital he was not shocked and was operated on three hours after injury. A metal fragment had perforated the bladder from before backwards and lodged in the peritoneal cavity, its velocity was only sufficient to damage the sero-muscular tunics of the sigmoid, but enough heat had been retained to burn the gut in two places.

Perhaps the most dramatic type of abdominal injury produced by a 'rocket-bomb' was described to me by John L. Stephen, of Dulwich Hospital.

**Case**—A woman of 52 had her abdomen impaled by a rafter beam, when a large fragment of an exploding V-2 passed through the roof of her home. To release the patient from the wreckage under and by which she was pinned, the beam of wood had to be sawn through on each side of the woman's body. On admission to hospital the patient was profoundly shocked. A piece of timber varying in diameter from 2 in to 3 in and measuring 2 ft in length protruded from a jagged hole below the 12th rib in the right lumbar region, its other end projected through another rent in the abdominal wall in the left iliac fossa. The wounds of entry and

exit were excised and joined by an oblique incision across the belly in order to lift out the beam. The beam had traversed the peritoneal cavity and passed through the great omentum, but the colon, though badly bruised, was not perforated, and the small gut had not been lacerated. From the coelom more than 1 lb of assorted splinters and ceiling plaster was removed. The muscles of the abdominal wall were grossly lacerated and necrotic, there was some bruising of the inferior pole of the right kidney which was exposed at the bottom of the lumbar wound. The patient also presented other severe wounds, one in the lower part of the right side of the neck exposed the subclavian artery and vein, another wound across the right wrist had severed radial and ulnar arteries, while from a laceration in the left groin a jagged piece of wood has passed down along Hunter's canal almost to the knee, fortunately without damaging the femoral vessels. The patient's convalescence was reasonably smooth and the large irregular abdominal wound healed soundly without suppuration or the development of a hernia (Fig 277).

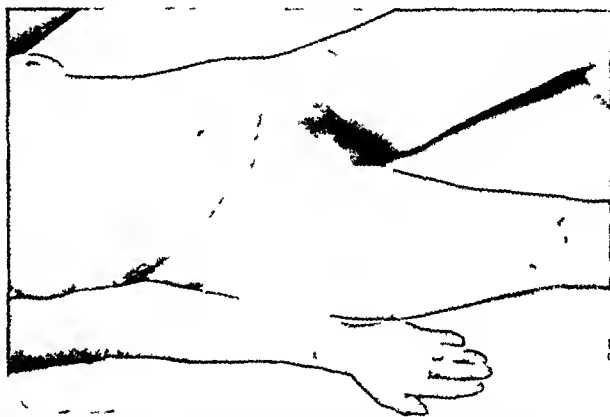


FIG 277—Photograph of patient whose abdomen was impaled and transfixed by a piece of timber in rocket-bomb explosion, depicting the length of the wound excision and the final state of repair (J L Stephen's case)

Another dramatic case was that of a railwayman crushed between two railway trucks at the moment of a 'rocket incident'. This was a magnificent result in the hands of Desmond Cooper, for the patient recovered from a resection of 8 ft of small intestine and the suture of another laceration. In addition, the man had sustained a disruption of the symphysis pubis and a fracture-dislocation of the right sacro-iliac joint.

A little girl of 12 years of age under the care of J T Laurenson recovered from multiple injuries due to a 'rocket incident', which included a separation of the mesosigmoid from the bowel for a distance of 5 in or 6 in, the colon was already becoming gangrenous at operation. Recovery followed an exteriorization technique.

A woman recovered in St Bartholomew's Hospital from multiple injuries due to a V-2 explosion on March 8, 1945. An enormous bomb fragment, measuring 4 in x 6 in, was removed from the right hypochondrium, the 8th and 9th ribs were shattered, and liver, gall-bladder, and colon were herniated through the wound. Ultimately an excellent recovery followed (Case of Harold Wilson).

Very severe damage to the liver is compatible with survival. In the last war recovery followed



wounds where portions of the liver were found free in the *cœlom*. One such case due to a 'rocket-bomb' was successfully operated on by W E Joseph, of Whipp's Cross Hospital. A fragment of liver, 3 in  $\times$  2 in  $\times$  1 in had been avulsed from the liver mesial to the gall-bladder, the boy of 15 recovered.

More rarely organs such as ovaries and Fallopian tubes have been damaged and successfully treated along with other injuries (Case of S H Wass).

### ABDOMINAL INJURIES DUE TO SHELL-FIRE ON DOVER

A soldier belonging to the Army of a great Ally, a GI, ETOUSA, while visiting Dover during the period of shelling from the guns at Cap Gris-Nez, and while happily and eagerly with some girl-friends seeing the sights, doubtless hand-in-hand—*O felicitas curiosa*!—received multiple injuries from an exploding shell, a fragment of which penetrated his abdomen, producing wounds of anterior and posterior surfaces of the stomach, there was much blood in the peritoneal cavity. Clinical evidence of acute intestinal obstruction necessitated a second laparotomy on the twelfth day after wounding, a coil of jejunum had attached itself firmly to the pelvic floor. The loop of gut was freed and subsequent convalescence was uninterrupted (T J Cobbe's case).

*Case*—A woman in a Church Army hut had a shell explode at her feet. The devastating character of her perineal injuries may be gauged from the accompanying photograph (Fig 278). An inguinal colostomy was performed and suprapubic drainage of the bladder instituted. Her recovery was despaired of in the early days after wounding, but her progress towards convalescence appeared to be materially influenced by the institution of penicillin therapy. Her bladder sphincter had fortunately escaped damage, and sphincter control of her rectum



FIG 278—Severe shell-fragment wound of perineum (Mrs G M B Toland's case)

had not been completely destroyed. The province of the plastic surgeon has no territorial limits, his skill in repairing the ravages of war even in the less conspicuous regions of the body equals that which he has manifested so signally in the restoration of facio-maxillary mutilations or of damaged or burnt extremities. Of him it may often be said—

"And ne'er did Grecian chisel chase  
A Nymph, a Naiad, or a Grace  
Of fairer form or lovelier face"

My colleague, Rainsford Mowlem, has effected a miracle of repair in this *grande blessée* (Fig 279) (Mrs G M B Toland's case).



FIG 279—Same case. Wound of perineum in process of repair, the 'reconstructed vaginal and anal orifices are reasonably well shown' (By courtesy of Rainsford Mowlem)

Another casualty had suffered a mutilating, lacerated wound of the right flank which had involved the crest of the iliac bone, the glutei, and muscles of the abdominal parietes, and had laid bare a lacerated cæcum and ascending colon in the depths of the carnage. When seen by the Receiving Medical Officer, he said "Don't bother about me. You get on with the others. I shan't live through this at my age."

Blood transfusion was started and he was taken to the theatre at 4.35 a.m. Hæmorrhage was arrested, and such toilet of the wound performed as his condition permitted. A Paul's tube was tied into the exteriorized cæcum. True to his own prophecy, he died three hours after operation.

*Case*—Emily A, aged 36, was admitted to Dover Hospital on Sept 25, 1944, as a casualty from enemy shelling. There were two lacerations involving the peritoneal cavity, evidently entry and exit wounds, each about 3 in in length, and situated in the upper left abdomen. Through the anterior wound the liver and everted stomach could be seen, through the posterior rent the colon was protruding. There were also numerous punctured wounds of both legs, one producing a fracture of the left fibula, a wound of the right buttock had a retained shell fragment, there was also a laceration of the neck. The pulse-rate was 134, the blood-pressure was unrecordable. At operation, performed three and a half hours after wounding, when 4 pints of blood had enabled a systolic blood-pressure of 100 mm to be registered, several lengthy vertical fissures of the liver were found, which were sutured with catgut. The spleen was pulped and was removed, a partial detachment of the diaphragm from the costal outlet was repaired, but the extraordinary lesion was that of the stomach, which was rent from near the cardia to the pylorus for a length of at least 6 in, the viscus being

turned inside out. The gastric laceration was responsible for most of the bleeding which had taken place and was still continuing at the operation. The gastric contents had been poured out under the diaphragm—an eloquent reminder of food-rationing and the value of 'allotments', carrot and cabbage were hastily scooped out, the everted stomach was restored to anatomical normality of shape, and the lengthy tear was sutured in two layers.

A left-sided pleural effusion required aspiration, but the patient ultimately made an excellent recovery (G Gordon-Taylor's case).

### SUMMARY

1 The abdominal injuries received during the V-1 and V-2 phases of the war on Britain and during the protracted shelling of Dover were *not* numerous.

2 The recovery-rate of proved abdominal visceral injuries due to 'flying-bombs' and treated by laparotomy was no less than 76 per cent.

3 The recovery-rate of the abdominal visceral injuries due to 'rocket-bombs' was 56.6 per cent, and of the few Dover casualties 83 per cent.

This paper could not have been written without the loyal and ungrudging help of the surgeons of

that South-east 'bit' of England, including the London area. The inescapable anxieties of an environment in which surgeons, men and women, of every age have laboured so loyally and devotedly and with such conspicuous success during more war years than the period under review prompt these lines written two thousand years ago as applicable to their philosophy and spirit.

*"Dum loquimur, fugerit invida  
aetas carpe diem, quam minimum credula postero"*  
(Horace, Odes I-II)

, "each word we say,  
Some envious moment melts away,  
Trust nothing to the morrow, live to-day"

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## THE GERMAN HOSPITAL CENTRE AT ABANO TERME

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SURGEON AND ANAESTHETIST WITH A FIELD SURGICAL UNIT, CENTRAL MEDITERRANEAN FORCE

AFTER the cessation of hostilities in May, 1945, instructions were received to act as Surgical Adviser to the British Cadre appointed to administer a collection of German Field Hospitals taken over by the Eighth Army.

The patients were grouped in thirteen scattered hotel buildings in the spa town of Abano Terme, North Italy, the area having been used as a medical centre for the previous eight months.

Contrary to expectation, the conditions of hygiene, nursing, and surgical treatment were found on arrival to be extremely unsatisfactory and well below British standards, and so bad were they that it is considered that an account of both these and the action taken to improve them is worthy of record.

In order to present a fair picture an attempt has been made to outline the official German surgical policy and to contrast this with the clinical evidence available, records of fatal cases, and, when necessary, with corresponding British methods and the evolution of these since the period before Alamein.

This report on conditions and the action taken for their improvement has been subdivided under the following headings: (1) General hospital hygiene, (2) Asepsis, antiseptics, and nursing, (3) Surgical clinical survey, (4) Blood transfusion and penicillin therapy, (5) Survey of medicine, anaesthetic, and V.D., (6) Analysis of deaths in hospital, (7) Summary of standard German methods in war surgery, (8) Discussion.

### GENERAL HOSPITAL HYGIENE

The hospital area as a whole had approximately 2500 available beds, of which a varying number in the region of 2000 were occupied. A tour of inspection of the individual buildings revealed that certain of these were more suited to nursing and operative treatment than others. Overcrowding and cross-infection were accompanied by inadequate grouping of the cases.

The hospital organization was based on a number of individual field hospitals, each with its own independent administration, and accordingly cases of all types were intermingled in each hospital. An odour of stale pus hung round most of the wards and corridors, and the patients in these lay, thin and waxy-pale, varyingly crowded together, on "scruffy" beds of every size and shape. In some buildings more effort had been made to improve the hygiene and asepsis, and one was immediately struck by the different atmosphere and the fact that the wounds in these wards were usually healing cleanly. Bed-bugs and lice were not common. The condition of the bedding was good, but an unnecessary quantity of furniture congested the wards. Water was plentiful, as the spa town is centred on a number of hot springs, and most buildings were fortunate in possessing a constant supply of hot and cold water from their taps. The 'natural' waters were said to contain iron and sulphur, and it was found that one scoopful of W.S.P. per 100 gallons was required to render it drinkable.

Attention was first directed to improving general ventilation and removing all unnecessary furniture from the overcrowded rooms and corridors. The bed state of each building was reviewed, 1000 cubic feet being adopted as a minimum standard for each bed. At the same time, sites were selected for the establishment of special centres for certain groups of cases, their situation depending on the requirements of the different groups and the suitability of the various buildings. This reorganization was carried out with the aid of a series of clinical survey forms, one from each building, to be described below. Wherever possible the most seriously ill patients were placed under the best conditions, and lighter cases were transferred by ambulance to the less pleasing available accommodation.

Every building had electric light and good water sanitation.

### ASEPSIS, ANTISEPSIS, AND NURSING

The standard of asepsis was fair in one or two buildings, but very low in many. This was due to a combination of factors. First, a gradual lowering of aseptic discipline induced by the Italian and the severe Russian campaigns, second, a recent period of overwork associated with defeat, third, inadequate forward surgery, and fourth, poor treatment and nursing since arrival at Abano.

Sepsis was evident at every turn. Many cases had reached the hospital with already septic wounds, their sepsis being largely attributable to inadequate forward wound excision, even when allowance is made for the delays due to the harassing of lines of evacuation. Cross-infection must have been the primary cause in many, and reinfection at the time of subsequent operation or dressing in others. Most dressings were carried out in a way which compared unfavourably with the methods one might adopt in a crowded casualty or M.I. room under difficult conditions. Bandages and dirty dressings were removed and re-applied with the fingers, and washing of the attendants' hands and forearms, and the use of sterilized instruments or bowls for major dressings had largely been dispensed with. Masks and theatre gowns were not worn, and sterile towels were noticeable only by their absence. In one theatre we entered, the floor was being swept with a broom while an operation was in progress, and in another an autopsy was being carried out. Most theatres had no sterile drums or dressings. Shaving, soap and water toilet, and skin preparation were inadequate. Instruments were boiled, but were sometimes laid out on non-sterile paper sheets. One doctor, indeed, was seen to put apparently sterile gloves on to unsterile hands. Cases of all degrees of sepsis were treated side by side in the same theatre.

It was first decided that each building must have two theatres. In one the dressings of all septic cases fit to be brought from the ward were changed, and grossly septic operations performed. In the other, redressing of clean cases and aseptic operations could be undertaken. Orders were given for the wearing of masks and a general tightening up of aseptic practice in both theatres and wards.

At the same time cross-infection was reduced

by a re-distribution of cases as described in the next section. It was found, for instance, that nearly one-third of all wounds, including even minor cases, had sepsis and fever for more than four days, and orthopaedic cases were being treated side by side with septic chest wounds. In fracture cases the oedematous and granulating wounds were reached through windows in the plaster-of-Paris casts. When copious pus was flowing, a bowl could be found beneath the window to collect it, and a swarm of contented flies completed a pre-Listerian picture.

The treatment of these septic wounds had been by applications of rivanol or sulphonamide and by water compresses applied at two- or three-day intervals. The policy now adopted was one of daily dressings with Dakin's solution under clean conditions, followed by the application as soon as possible of closed split padded plaster casts. Secondary suture was obviously not yet practicable. Deep wounds were irrigated with eusol through rubber tubes introduced deeply.

There appeared to be no central nursing organization and the nursing appeared in general haphazard. Temperature charts, however, were well kept, and the nursing approach to the patient was satisfactory, although of an unskilled, 'field' type. There were some 200 nursing orderlies, but only 20 available trained German nursing sisters.

There were 4130 sheets, mostly of poor quality. The washing and allocation of these was not well controlled, thus causing a relative shortage among the more severe cases. Soap, towels, and crockery were all scarce.

Beds were fairly evenly divided into three types: wooden hotel beds, iron hospital-type beds, and divans. These, too, were badly distributed as between severe and slight cases.

Bed patients were ill washed, beards and long hair were much in evidence, and bed-sores commoner than is usual.

The nursing staff was reorganized with the aid of a senior sister chosen to carry out duties in the wards comparable with those of an assistant matron. The available skilled nurses and orderlies were directed towards those centres where they were most needed, and a personal tour of every room in every building was made in company with our nursing adviser to ensure that the available space was used to the best advantage.

About 70 per cent of the beds were classed as 'good', and these were redistributed as most needed among the severer cases. Wherever possible a clear floor-space was made round the sides and bottom of each bed.

Instructions were given in each block for the collection of personal equipment into a pack store, as it was found that it was causing unnecessary congestion and collecting dust.

The theatre methods, their siting, and their equipment, were redirected with a view to approaching British standards of asepsis.

The method of distribution of food was examined. Efforts were made to obtain crutches and fracture-boards, and such articles as toothbrushes, nail brushes, shaving soap, blades, and so on.

Finally, application was made to higher authority for the supply of further skilled nursing staff.

## CLINICAL SURVEY

The hospital centre consisted of a series of field hospitals which worked and were supplied for all practical purposes, independently of each other. Each hospital admitted any type of case except head injuries and maxillo-facial, eye, and E.N.T. cases, which were grouped in one hospital. Operating and X-ray equipment were satisfactory.

To assist the control of future policy, it was necessary to re-group the patients according to their clinical diagnoses and state of sepsis. It was considered that this would also lessen the chances of cross-infection and enable the available theatre and special equipment to be used to the best advantage. When a tour of the patients and individual blocks had been made it became evident that certain blocks were suitable only for the treatment of light cases, as they were dark and ill ventilated, having narrow corridors and small rooms. Other buildings were of more recent construction, with large rooms suitable for wards, wide corridors, good hygiene, and good water supply. The policy adopted, therefore, was to make each building into a centre for a particular type of patient, sending the light cases to one, chest cases to another, amputations to another, and soon. Information had also been received that evacuation was likely to be stopped soon, and that a further thousand admissions might be expected. A reception centre in a hotel building at the entrance to the area was therefor established.

It became evident that many patients suffering from the effects of chronic sepsis would require blood transfusion and penicillin to save their lives. A clinical survey form was prepared, showing in twelve columns the important facts relating to each class of patient. Classification was by both patients and lesions. With the aid of this record we were able to pick out rapidly the light cases (R.T.U. in 3 weeks), those liable to need penicillin (septic wounds with over 4 days' fever), those requiring blood transfusion, and so on. The 'general post' necessitated by the unification of the hospital group was thus greatly facilitated.

This consolidated form gave a broad picture of the sickness state of the hospital group at the time. There were, for example, 62 patients with wounds involving the dura mater, 181 lower-limb amputations, 87 penetrating chest wounds, 55 fractured femurs, and 50 wounds involving the knee-joint. Some 368 had had fever for over 4 days with septic wounds, 15 had bed-sores, and 177 were classed as dangerously ill and unfit to be moved.

We were now in a position to discuss the relative value of various surgical treatments with individuals, and to know that the result would equally affect a number of similar cases.

At this time the deaths were numbering 3 to 9 each day. Our aims, therefore, were, first, to obtain without delay a clear view of both the orthodox and the actual German surgical policy in any particular class of case, secondly, in the light of this knowledge to anticipate any persistent errors and their consequences.

Accordingly the most experienced German surgeon was requested to write for us a brief account of German war surgical practice. At the same time,

we compiled with the aid of our German doctor interpreters, brief summaries of all the fatal cases of the month.

The same surgeon was appointed to act in a position similar to that of a British O.C. Surgical Division, and to give effect to such clinical instructions as were issued by us from time to time.

British Field Medical Cards were initiated with short digests of the German notes for —

1 All patients about to be evacuated to British hospitals

2 All patients who received penicillin

3 All patients likely to be repatriated with serious permanent disabilities

Daily ward rounds were made, and the following clinical observations arise from them —

**Flesh Wounds.**—These had been, as a rule, inadequately excised. Some healed by granulation. In others there was 'phlegmon' followed by abscess formation, and this had been treated by incision and drainage. The drain was usually left in too long, causing excessive granulation and delayed healing. Our policy was that of daily eusol dressings until clean, to be followed when possible by either secondary suture of skin-grafting, with the aid of penicillin if available.

**Amputations.**—Guillotine operations had almost invariably been performed. A healing period might be hoped for from these lasting 6–8 weeks, if granulation and epithelialization proceeded normally. Definitive re-amputation, with delayed suture if this was considered necessary, could be carried out some three or four months after wounding.

Most of them, however, did not run so smooth a course. A spread of infection to the knee-joint or along the femur, with femoral, pelvic, or even renal thrombophlebitis followed frequently, and re-amputation was sometimes done in an attempt to prevent this. The tying of veins to prevent the spread of thrombophlebitis was fairly frequently carried out. Our policy aimed at the performance of an elective amputation as early as possible, through a penicillin screen with delayed suture and drainage. All wounds were given a course of daily eusol dressings to clear up the gross sepsis before this could be attempted.

**Orthopaedic Cases.**—Limb plasters were on the whole inefficient, and failed to allow good finger and toe movements. Abduction plasters were satisfactory, but above-knee casts were too short and below-knee casts too high.

It was the German custom to transport femur cases after primary wound excision in hip spica, and some were still being treated in hospital by this method. Others were being treated by the normal Base method of sliding traction in bed with a Braun splint and a Kirschner wire applied through the tibia. This method was encouraged after the cases were removed to the fracture centre.

Penetrating knee-joint wounds were normally treated by a hip spica, the joint being aspirated at the Base. When severe sepsis appeared, joint excision was carried out, the upper end of the tibia and the lower end of the femur being resected and the wound being left to drain through a windowed plaster applied from the toes to the umbilicus. This operation in the face of sepsis resulted usually

in osteomyelitis of the femur and tibia, and death was liable to follow unless amputation was undertaken, owing to the spread of sepsis.

Plasters applied to fractures were nearly always windowed in one or more places, and invariable unsplint.

Healing of wounds with fractures was by granulation. Primary, delayed, or secondary suture was not attempted, and had, in fact, been forbidden by the German medical authorities. The period of disability was consequently a long one.

Stiff limbs and venous stasis with thrombosis were associated with a backward attitude towards physiotherapy.

**Cranial Surgery**—This was adequately carried out by the neurosurgical specialist under good aseptic conditions. The time-lag of fresh cases had varied considerably. In early cases the policy adopted had been excision of the wound, using a sucker and methods similar to our own, with primary suture, and the results were satisfactory. The older cases had been treated by a modified excision without closure. The wounds were encouraged to granulate from below, and this was assisted by the placing of a small sterile sponge in the wound. When, later, penicillin was given, it was applied either locally, intrathecally, intramuscularly, or by a combination of these methods. It is too early at present for any estimate to be made of the results of penicillin in these late cases.

**Chest Surgery**—Primary closure of sucking wounds with excision was the usual policy. Non-sucking wounds were excised, left open, and allowed to heal by granulation. Early aspiration was usually possible, but nearly every penetrating chest wound resulted in an empyema. This was treated by aspiration. When aspirations became difficult, an intercostal space drainage by the Bulau tube method was usually adopted. This was frequently inadequate, and the continuous prolonged pyrexia which followed called for rib resection or thoracotomy. A number of cases had died of septic toxæmia through the neglect of these more radical measures.

It was therefore arranged, in consultation with the senior Boland and Stammers, that all chest wounds should come under the care of one surgeon who had experience of chest surgery. Penicillin was instilled at the time of aspiration into cavities which were suitable. A separate theatre was prepared, and all necessary chest operations were carried out as soon as possible.

The standard of treatment of penetrating chest wounds before this could be classed as 'bad'.

**Abdominal Surgery**—There were fewer abdominal cases than might have been expected, mainly because abdominal cases were usually operated on in the German field ambulances and forward hospitals, and were not evacuated from these until fit to travel.

These cases were treated in general on lines similar to our own, except that the wounded colon was commonly sutured and replaced. Infusion, transfusion, and gastric suction were rare, and either suprapubic cystostomy or an indwelling urethral catheter was used to drain the bladder.

**Progress**—The number of admissions and discharges varied, there being any number up to

50 of either on any one day. Seven weeks after the end of April (on June 16), although there were 1440 surgical patients, of whom 1062 had clean wounds and no fever, there were still 252 who had septic wounds and had had fever during the previous four days. These included, correspondingly, fractured femurs (54 and 13), penetrating knee-joints (54 and 18), lower-limb amputations (159 and 39), penetrating brain wounds (43 and 4), and penetrating chest wounds (48 and 41). There were still 120 who required blood transfusion and 78 and 35 patients were now classed as dangerously and seriously ill respectively. There were 560 cases which were considered only fit to be moved within the hospital area, 242 were expected to return to duty within 3 weeks, and 525 within 2 months.

By the end of the June quarter 117 re-amputations, 48 secondary sutures, and 17 skin-grafts had been performed, and 868 patients had been returned to duty. A total of 315 had been classified as suitable for repatriation under the international standard.

It is not possible to offer a fair or scientific comparison between German and British War Surgery entirely on the results seen at Abano Terme, but the following observations are put forward without comment. Simple wounds treated successfully by delayed suture are as a rule healed within 3 weeks of the time of wounding and those by secondary suture within 5 weeks. In one series (Parish) totalling 3845 flesh wounds treated by delayed suture (2693) and secondary suture (276) at 20 different general hospitals in the C M F during September–October, 1944, 90 to 100 per cent healing was recorded in 78 per cent and 67 per cent of the wounds respectively. Another series (Macdougall) of 43 amputations at a similar period gave with delayed suture 87 per cent and with secondary suture 50 per cent successes on similar standards. A mortality-rate of 2.7 per cent and an amputation-rate of 3.7 per cent were recorded in a third series (Furlong) of 218 compound fractured femurs, and in one group of these, numbering 38, treated by intramuscular penicillin and complete suture, 53 per cent were completely healed and 87 per cent had "bone shut off" after eight weeks.

In North Africa, before penicillin was available, an empyema rate of 33 per cent in hæmothoraces was recorded (Nicholson) and a control series of fractured femurs treated in the C M F without penicillin gave an amputation-rate of 8.5 per cent and a mortality of 8.5 per cent.

## BLOOD TRANSFUSION AND PENICILLIN THERAPY

**Blood Transfusion** (in collaboration with Capt Borrowman of the Blood Transfusion Service)—Cases were selected for transfusion on their clinical appearance, general state of nutrition, and toxæmia, checked by a hæmoglobin and red-cell estimation. Equipment and facilities for the copper sulphate plasma-protein method were not available at first, but were obtained later.

A preliminary survey on this basis showed that there were 497 cases requiring transfusion, of which 224 were below 60 per cent Hb, and since the

majority of these would require 3 to 4 bottles each it was estimated that 800 to 900 bottles would be needed during May

Blood transfusion had previously been given by the German Staff by the direct arm-to-arm method, and in small quantities (200–250 c.c.) It was considered that this method was too slow, and, in view of the numbers to be treated, arrangements were made for a field transfusion unit to undertake the instruction of the German Staff in the indirect method, using British equipment

The sources of blood that were available were P.O.W.s' in transit at 373 P.O.W. Camp, north of Mestre, and the German Staff at Abano. It was decided to obtain as much blood as possible from the prisoners while this source lasted, and to use the local staff as a reserve

German officers and men were selected to form a Hospital Blood Service and demonstrations were given in grouping, and taking and giving blood by our methods. A team of bleeders was formed and was transported to the P.O.W. Camp on the days donors were available to bleed

Donors were selected from men between the age of 20 and 30 who had no history of malaria, jaundice, or V.D. The group stamped on the identification disc was checked before bleeding, and cross-matching was done before transfusion. All groups were used. No cases of mismatching were reported. The blood taken was held in a hospital refrigerator under the charge of an officer who was also responsible for the general supervision of the Service. A team of givers carried out the treatment in the various hospitals

From May 14 to 31, 1945, 923 bottles of blood were collected and 801 bottles were given, leaving a stock of 122 bottles in hand. The percentage of the different groups given were A 42 per cent, B 10 per cent, O 44 per cent, AB 4 per cent, and during June a further 801 bottles were collected, of which 789 were given

A large number of the cases showed evidence of chronic sepsis with pyrexia, yet in only 44 cases were reactions noted. 26 cases had a rigor, 4 developed urticaria, 1 had hæmaturia, and 5 showed mild circulatory disturbance. No jaundice or anuria were reported. No deaths occurred

During May the blood was used at an average rate of 45 bottles a day and at an average age of 2 days, 344 transfusions were repeated. During June the average was 26 bottles a day, with 637 repeat transfusions. Some of these were given before, during, and after operations

The results as judged by the improvement in clinical condition were very satisfactory

Hæmoglobin and R.B.C. estimations were carried out on a series of 46 cases with Hb below 70 per cent and the following results were obtained —

Average reading before transfusion	2,900,000 R.B.C.,	57.7 per cent Hb
" " after 4 bottles	3,500,000 R.B.C.,	77 " " Hb
" " " 6 "	3,900,000 R.B.C.,	79 " " Hb
" " " 8 "	4,100,000 R.B.C.,	81 " " Hb

The usual interval between doses of 500 c.c. was 4 days

**Penicillin Therapy**—The group of cases in Abano presented us with an unrivalled picture of sepsis in war surgery. It became clear very early

that here was an ideal opportunity for research in the treatment of this type of case. Penicillin was required urgently for treatment all over Italy, but permission was granted after a short delay for penicillin to be used on German P.O.W.s' when it was necessary to save life. (Penicillin was also allowed for some sulphonamide-resistant or salvarsan-sensitive cases of V.D., for economic reasons)

Surgical cases chosen for penicillin treatment were examined personally by us, and were all suffering from prolonged and severe sepsis with pyrexia. The ruling was made that all necessary surgical operative treatment must have already been performed, and that blood transfusion must have been carried out wherever necessary before penicillin was started, the supply of blood, under the supervision of the transfusion unit, being now plentiful

The usual precautions were observed in the matters of supply and safe storage, but bacteriological control was not possible until the later arrival of Major Scott-Thomson. In consultation with him we were then able to choose cases of chronic sepsis for penicillin not only for the purpose of life saving, but also for research into the action of penicillin on these cases by varying methods

Bacteriology and the supply of penicillin were now undertaken by the penicillin team. A further report of these investigations will be made at a later date

Our policy was to use massive doses on a small number of cases and to determine whether they could so control the sepsis that definitive surgical measures could be undertaken. Penicillin was given by intramuscular injection, by local irrigation, and by deep local injection down to the site of fracture using a long needle

Secondary suture, re-amputation, and early skin-grafting were encouraged, and the German surgeons instructed in the use of penicillin and methods such as the tube technique. Local application of solution or powder was made the procedure of choice, with additional parenteral penicillin when necessary

## SURVEY OF MEDICINE, ANÆSTHETICS, AND V.D.

**Medicine.**—Apart from the question of tuberculosis, the medical side presented no problem comparable with those of the surgical. There were some 350 medical patients on our arrival, including cases of tuberculosis, convalescent infectious disease, nephritis, infective hepatitis, rheumatism, undulant fever, recurrent malaria, skin diseases, and "minor sick"

Clinical diagnostic methods were thorough, and records were meticulously kept. The loss of the German mobile bacteriological laboratory, which had been sent away shortly before the end of hostilities, was a handicap, but clinical side-rooms undertook routine examinations of blood, urine, and sputum

Treatment, though tinged with the academic, appeared sound and well carried out. A rigid and well-controlled Vollhard diet, for instance, was the rule in cases of nephritis. The scheme of malarial treatment approximated very closely to the current British scheme, except for the preliminary quinine



Skin cases were treated on familiar lines. It was interesting to note the same mental resistance to the conception of sulphonamide dermatitis as is still encountered in the British medical services.

The empirical treatment of the rheumatic group of diseases was given local colour by occasional mud baths and immersion in the spring waters of Abano.

Sulphonamides were prescribed orally with discretion and common sense.

Strophanthin was a favourite drug which tended to appear on charts whenever pulse-rates rose rapidly from any cause. Polypharmacy, however, was less in evidence here than on the surgical side, where it ranged unfettered and unquestioned, reaching its full fury as the patient neared his end under a broadside of coramine, adrenaline, strophanthin, calcium, caffeine, tutofusin, and eupaverin. "Trotz starker Kreislaufmittel tritt der exitus letalis ein" is the routine description of this process.

**Tuberculosis**—Owing to recent admissions there were 84 tuberculous patients in the hospital centre. Of these 50 per cent were considered moribund by the German medical officers in charge of them, but we regarded this as too pessimistic an estimate, given reasonably good conditions for their treatment.

Unfortunately the heat and steam of the ubiquitous sulphur springs of Abano Terme provided a very unfavourable climate for the treatment of tuberculous patients in the summer, and the block which we had set aside provided poor accommodation for them. There were two cool airy wards with room for 20 beds apiece, and the rest had to be lodged in small and often stuffy hotel bedrooms. A more suitable building was being sought for them, in the neighbouring hills, so far without success.

Most of the worst cases were Russians, primitive in their outlook and habits, and unwilling to co-operate in their treatment with their German medical attendants. There were also some 25 Serbs, who had been treated with obvious efficiency for several months in German hospitals in Vienna and Laibach.

We obtained a pneumothorax apparatus from an Italian civilian sanatorium in Padova, and the X-ray apparatus was adequate. Some 10 of the patients had "A.P.'s" already established.

**Venereal Disease**—On our arrival the V.D. department contained approximately 34 cases of syphilis, 22 cases of gonorrhœa, and 3 or 4 of soft sore.

Syphilis was treated by standard arsenical methods, efficiently controlled by Wassermann and Kahn tests.

Treatment of gonorrhœa was not satisfactory, the rate of primary cure being estimated by the Germans as 35 per cent. This was probably due to the fact that the standard 3-day course of treatment consisted of a preliminary artificial pyrexia produced by olobinthin or pyrifur, followed by a total of 18 g. only of sulphathiazole. Of the 22 cases 17 were in various stages of sulphonamide resistance. These were rapidly cleared by the standard penicillin course of 100,000 units.

An antisyphilitic course of penicillin had also been initiated in two cases of generalized exfoliative salvarsan dermatitis, with heavy secondary infection. These showed a dramatic clinical improvement.

**Anæsthesia**—Anæsthesia was best described as of 'continental' quality. Local novocain infiltration was used more freely than in British or American practice, producing a partial analgesia which satisfied at least the surgeon.

Premedication was fortunately efficient, 'S.E.E.' (scopolamine-ephedrin-eukodal) mixture being used for this in ampoules of three standard strengths. It was considerably used as a potent intravenous narcotic for moderately painful procedures such as removal of plasters and difficult dressings, and even for the reduction of dislocations.

Evipan sodium or 'rag and bottle' ether with ethyl chloride, evipan, or open ether induction, were the methods of general anæsthesia. Nitrous oxide was not recognized as an anæsthetic agent, and endotracheal intubation was regarded as a purely theoretical possibility.

## ANALYSIS OF DEATHS IN HOSPITAL

Brief summaries of a number of fatal cases during the month were made with the help of our two German doctor interpreters, and the following analysis of these has been made in order to give a broad picture of the main causes of death.

	<i>Mode of Death</i>	<i>Totals</i>
Head wounds involving dura	Primary shock and brain damage	4
	Hæmorrhage	2
	Meningitis	14
		— 20
Penetrating chest wounds	Empyema	13
	Empyema with secondary hæmorrhage	4
	Empyema with subphrenic abscess	1
	Primary hæmorrhage	3
	Pneumonia with hæmopericardium	1
	Pelvic thrombophlebitis	1
		— 23
Penetrating abdominal wounds	Peritonitis	11
	Hæmorrhage	1
		— 12
Thoraco abdominal wounds	Primary hæmorrhage or shock	2
	Empyema	3
		— 5
<b>Amputations—</b>		
Above elbow	Anaerobic cellulitis	1
Below elbow	Septicæmia	1
Above knee	Septicæmia	3
	Septicæmia and secondary hæmorrhage	1
	Septicæmia and pelvic thrombophlebitis	2
	Septicæmia, pneumonia, and empyema	3
	Septicæmia and fat embolism	3
	Fulminating gas gangrene	1
	Tetanus	1
Below knee	Septicæmia	4
		— 20
Fractured spine without paraplegia	Septicæmia	1
		— 1
Fractured spine with paraplegia	Primary shock	1
	Hypostatic pneumonia	2
	Urinary infection (no suprapubic cystostomy)	3
		— 6
Fractured pelvis without bladder lesion	Septicæmia	1
		— 1
Fractured pelvis with bladder involved	Primary shock	1
	Peritonitis	1
	Urinary infection	1
		— 3



	Mode of Death	Totals
Compound fractured femur (without amputation)	Primary shock	1
	Septicæmia	3
	Septicæmia with secondary hæmorrhage	1
	Tetanus	1
		— 6
Compound fractured tibia and fibula (without amputation)	Septicæmia	1
	Septicæmia with embolism	2
		— 3
Compound fractured forearm	Tetanus	1
		— 1
Compound fractures involving joints—		
Shoulder	Septicæmia	1
Knee	Septicæmia	4
	Septicæmia with secondary hæmorrhage	1
	Septicæmia with pelvic thrombosis	2
	Septicæmia with lung embolism	— 9
Burns	Tetanus	1
		— 1
Flesh wounds	Primary shock	1
	Septicæmia	4
	Septicæmia with secondary hæmorrhage	1
	Septicæmia with liver abscess	1
	Tetanus	5
	Erysipelas	3
	Fulminating gas gangrene	1
		— 16
Wounds of large vessels— Carotid artery and vein	Secondary hæmorrhage, respiratory arrest under evipan	1
	Secondary hæmorrhage	1
Femoral vein		— 2
Appendicitis	Peritonitis	1
		— 1
Osteomyelitis of ileum (primary)	Septicæmia	1
		— 1
Hogdkin's disease	Empyema	1
		— 1
	Total	132

## NOTES ON METHODS IN GERMAN WAR SURGERY\*

(In collaboration with a senior German surgeon)

The treatment of wounds in the German Army should be carried out as stated in the Army Manual, *Instructions for Treatment of Wounds in the First Medical Units*, published by the German Command

In this Manual the following suggestions are made as to the treatment of wounds

### The First Medical Aid Post—

1 Saving of life by treatment of shock and collapse  
2 Transport and operations while in a shocked or collapsed state forbidden, except to save life, i.e., gross hæmorrhage, tracheotomy, and open pneumothorax

### Treatment of Shock—

1 Warmth—hot-water bottles and hot drinks  
2 Blood transfusion, periston, tutofusin, or serum  
3 Cardiac stimulants, i.e., coramin, cardiazol, camphor, hexeton, strychnine, strophanthin, sympathol, ventol, adrenaline

### Prevention of Asphyxia—

a Removal of the cause, i.e., pus and/or other secretions

- b Fixation of tongue
- c Removal of damaged tissues
- d Removal of foreign bodies
- e Tracheotomy
- f Suture of pneumothorax

### Treatment of Hæmorrhage—

a Pressure  
b Ligature  
c In extreme cases tourniquet, which must be released after a maximum period of two hours, and

\* This section is a modified translation from German notes

eased every thirty minutes, for a short period The patient must always be watched for signs of collapse

## FIRST TREATMENT OF WOUNDS ANTISEPTICS AND STERILE DRESSINGS

### First Treatment of Burns—

1 After washing with antiseptic solutions, dressed with prontosil gauze (sulphonamide vaseline gauze)

2 Burns brushed with 5 per cent tannic acid under anæsthesia This treatment is continued half-hourly or hourly until a leather skin is formed Tannic acid treatment is only used for the first 48 hours and when no other treatment has been previously used Attention is paid to circulation, and blood and serum transfusions are given

**Methods taken to Prevent Infection—**Every wound is treated as if infected The greatest precautions are taken to prevent secondary infection Sterile antiseptic dressings, limbs and wound kept quiet

Prophylactic tetanus 2500 units

With large wounds 8 c.c. A.G.G.S. is injected

Prevention of anaphylactic shock by sensitization test for A.G.G.S. and A.T.S.

Chemical treatment also

Local and general sulphonamide courses

### General Surgical Treatment—

1 *Through-and-through small bullet wounds* are treated conservatively No excision, sterile dressings, and kept quiet The same treatment is applied where there are fractures and when joints are involved, but only when the wound is the same size as that of a small bullet This type of wound is only operated on when synovial fluid is being discharged from a joint or when there is an open pneumothorax

2 *Other types of wounds* Total excision Removal of damaged tissues Total excision must be made within 12 hours of wounding Primary suture of all war wounds is forbidden It is possible to suture wounds which are clean, five to eight days old Primary suture of war wounds is allowed in the following instances (a) Head (involving brain) wounds, (b) Open pneumothorax, (c) Open wounds of joints

3 The principal method of treatment of war wounds is by excision The best results are achieved when the time-lag is less than 12 hours The method of treatment is determined by the anatomical state of the important structures Wound excision must be carried out in all large, deep, or lacerated wounds All debris and devitalized tissue, foreign bodies, and bone fragments being removed

Tamponade of through-and-through and penetrating wounds is forbidden Results retention, secondary infection, phlegmons Primary suture forbidden All mine wounds and shrapnel wounds must be surgically treated

4 *Metallic foreign bodies* may be removed only when they are superficial or when they are found during the operation It is forbidden to search for metallic foreign bodies in inflamed tissue

### Exceptions—

a Metallic foreign bodies near important vital organs (trachea, urethra, blood-vessels, nerves)

b Penetrating S.W. in brain

c Penetrating S.W. of joints (within 48 hours)

5 Local use of M.P. powder Sulphonamide treatment per os 2 days 8 g, 2 days 6 g, 4 days, 4 g

## SPECIAL SURGICAL TREATMENT OF WOUNDS

1 **Penetrating S.W. in Brain**—Primary operation as soon as possible Primary operation with good results as soon as possible until the fourth day

Exception Penetrating S.W. with large destruction of the head bones or infection

Before every head operation a radiograph in two planes must be taken Treatment of shock, and lumbar puncture

## Reason —

*a* Removal of bone fragments, metallic foreign bodies, and infective material

*b* Ligation of vessels

*c* Prevention of secondary infection

## Surgical method —

Wound excision Preparation of the dura in the healthy part 1 cm around the wound Aspiration of the destroyed and necrotic brain parts Removal of bone fragments and metallic foreign bodies Ligation of blood-vessels, primary suture of dura with a pedicle or free graft from the galea aponeurotica, periosteum, or fascia

The preparation of the dura depends on the amount of brain destruction and the condition of the dura Excision and flap closure are then done

In cases more than 4 days old or large brain wounds with infection, damaged brain tissues aspirated Bone fragments and metallic foreign bodies removed and open treatment established with rubber sponges or Mikulicz (this is a stout glass tube with closed end and perforated sides Discharges are mopped up from inside it periodically)

## Place for treatment —

Field hospital, if possible by brain specialists No transport before 4–6 weeks Rest after operation is more important than primary operation Operations are performed with local anaesthesia together with S E E (scopolamine, ephedrin, eukodal) or evipan

**2 Wounds of Face and Maxilla**—If possible, primary operation by specialist or dentist

*a* **Fractures**—Fractures with little displacement are treated by drilling and wiring of mandible, including as many teeth as possible Fractures with large bone defects are bridged with wire splint at primary operation In fractures of mandible with much displacement elastic fixation to the maxilla is done Fixation is best effected by plaster-of-Paris head cap with loops and rubber bands

*b* **Flesh Wounds of Face**—Wound excision Approximation suture only where there is free drainage If not, secondary suture after some days or weeks Operation on the face Local anaesthesia or S E E Nourishment by stomach tube Mouthwashes with antiseptic spray

**3 Wounds of the Eyes**—Primary treatment only by specialists within 12 hours Chemical burns irrigated with water or solution of 5 per cent soda bicarb (eye vaseline or noviform-vaseline-dressing) Wounds of lid primary suture Foreign bodies must be removed For intra-ocular foreign bodies X-rays in two planes are necessary For intra-ocular metallic foreign bodies a 12-cm magnet and X-ray equipment are essential Wounds of cornea and sclerotic and prolapsed parts such as the iris are resected and the wound closed with flap of conjunctiva

Corneal wounds are sewn up with sterile female hair Sclerotic wounds are sewn up with finest silk When the eye is destroyed enucleation is performed

**4 Wounds of Ears**—Most of them communicate with head wounds Primary operation is necessary as soon as possible Destructive wounds must be examined to see whether middle ear, temporal bone, or mastoid is fractured Retro-auricular exploratory incision must be made when necessary

Ear wounds caused by a blunt instrument (perforation of drum, lesion of internal ear) are treated conservatively, irrigations forbidden Labyrinthine and meningeal irritations must be operated on through a mastoid incision

**5 Neck Wounds**—Small penetrating wounds, afebrile, are treated conservatively

For wounds of oesophagus, external oesophagotomy is performed Nourishment is given by means of a stomach tube

Wounds of larynx and trachea Tracheotomy is performed Skin emphysema must be incised

Wounds of the large neck vessels must be sutured, if possible, when they are damaged If this is impossible they must be ligatured

**6 Chest and Lung Wounds**—Pneumothorax with high tension valve drainage Large hæmothorax must be repeatedly aspirated After shock treatment every open pneumothorax must be closed as soon as possible

Lung inflation apparatus during operation is useful Through-and-through wounds with no large opening of the chest can be treated conservatively

Wound excision, removal of rib fragments, and metallic foreign bodies Suture in layers

Large defects of chest wall can be closed by flaps Closing of defect by stitching lung into gap has bad results After operation dressing with elastoplast or jaconet Dressings are only to be changed in cases of hæmorrhage Uninfected chest wounds are treated conservatively by aspirations In cases of infection Bulau drainage must be applied at the lowest point

**7 Abdominal Wounds**—Every abdominal wound must be suspected of perforation of the peritoneum When the parietal peritoneum is wounded a laparotomy is necessary Likewise when symptoms of peritonitis are noticed Liver wounds must be closed by suture or plugged with gauze Destroyed spleen must be removed (splenectomy) Wounds of stomach and intestines are sutured When the colon is perforated a colostomy must be done When the intestines or the colon are wounded the operation depends on the extent of the injury If possible no resection After colon operation in every case A G G S must be injected Wounds of pancreas must be sutured and a transperitoneal tamponade applied Wounds of diaphragm are sutured All operations with ether anaesthesia or local anaesthesia

All abdominal wounds must be operated on within 12 hours if possible When there is a hope of good results abdominal wounds must be operated on even after 12 hours After operation a rest of 3 weeks is necessary

Localized peritonitis must be treated if possible conservatively General peritonitis must be operated on

All abdominal wounds must get antiperitonitis serum (40–80 c c intraperitoneal and 20–40 c c with infusion of tutofusin intravenously)

Post-operative nursing is important

**8 Wounds of Urogenital Tract**—Hæmorrhage and extravasation of urine must be looked for and dealt with if possible by extraperitoneal operation

When the bladder is wounded—laparotomy

Bladder wounds sewn up in two layers Catheter applied or, better, suprapubic cystostomy When there is an extravasation of urine, incision and suprapubic cystostomy Soft rubber catheter applied by urethra or from above through suprapubic cystostomy

**9 Wounds of Limbs**—Flesh wounds are treated according to the general rules of wound treatment Limb wounds involving bones are always infected compound fractures

Surgical treatment is necessary to avoid pseudarthrosis Bone fragments still attached by the periosteum must not be removed When a fractured femur is infected, the abscess must be incised and drained Early operation is more important than rest after operation

**Wounds involving Joints**—Treatment depends on extent of the joint wound and destruction of joint

*a* Penetrating G S W and through-and-through G S W are treated conservatively Sterile dressings, splint and synovial fluid aspirated

*b* When joint is open without fractures Irrigation only during the first operation is necessary Capsule sewn up, flesh wound left open, hip spica applied If possible, no change of dressing Infected joint wounds must be drained by a long lateral incision When the joint is still discharging resection of knee-joint must be performed

Wounds with destruction of joint Removal of foreign bodies and bone fragments Joint left open, and hip spica Resection of the joint or amputation depends on the extent of the destruction Joints not operated on after 48 hours with signs of infection must be treated with aspiration, irrigation with Klumsky solution (phenol-camphor), arthrotomy or resection Rest after operation more important than early operation

#### *Calf Wounds with Fractures —*

*Good* Plaster-of-Paris or plaster-of-Paris slab to upper third of thigh Foot in dorsiflexion Toes free on the dorsum

*Sufficient* Kramer wire splint to upper third of thigh

*Bad* All dressings not reaching upper third of thigh

#### *Wounds of Forearm with Fracture —*

*Good* Plaster-of-Paris from metacarpo-phalangeal joints to shoulder-joint Middle position of forearm, light dorsal flexion of the hand, and 90 per cent flexion of elbow-joint

*Sufficient* Kramer wire splint in the same position

*Bad* All dressings below shoulder-joint, or arm, hand, and fingers in other positions

When the limb is swollen plaster-of-Paris must be opened dorsally

*Amputations* —First point is to save life before saving the function of the limb

#### *Indications for primary amputation*

*a* When the limb is devitalized

*b* When there is no chance of recovery of the function of the limb

*c* In the presence of severe infection to save life

#### *Indications for secondary amputation*

*a* Progressing gas gangrene

*b* Discharging, infected fracture and joint wounds, dangerous to life

*c* Gas gangrene or fracture with damage to the main blood-vessels

*d* Repeated hæmorrhage from main vessels near fractured bones when ligature is not possible

*e* General infection spreading from the limb

*f* Empyema after joint resection, with pyrexia and bad condition for 2-3 weeks

*g* Tetanus, spreading from the distal part of the limb

*Technique of Amputation* Cut in the wound with removal of damaged skin and muscles Amputation of the bone above fracture When infection is present amputation above infection

*Secondary Amputation* Amputation with a flap, no primary suture In clean cases stitches inserted, closed after 5 days Periosteum and marrow left undisturbed

**10 Wounds of Vessels** —Suture of vessels has no place in Field surgery It is only possible —

*a* Under the best aseptic conditions

*b* When the wounds are clean

*c* Only large vessels can be sutured

#### *Contra-indications —*

*a* Septic wounds

*b* When the defect is larger than 4 cm

Operations on aneurysms can be made only in Base hospitals

**11 Wounds of Nerves and Spinal Cord** —In the Field, partially or totally divided nerves must be sutured Primary complete suture of the nerve must meet easily The wound must be aseptic In all other cases secondary suture of nerve

Treatment of lesion of spinal cord must be performed in Base hospitals

Surgical treatment is not urgent

Good nursing is necessary

Lamnectomy is indicated only for penetrating wounds or bone fragments in the spine, when the X-ray shows pressure on the spinal cord

## ORGANIZATION OF THE SURGICAL SERVICE IN THE FIELD

### **1 First Aid Post in the Line —**

First dressing, tourniquet, Field transport splint A T S injected

### **2 Advanced Dressing Station 1-4 km behind the Line —**

Revision of dressing (if possible, no change)

Tracheotomy, pneumothorax closed by dressing, making fit for evacuation, by treatment of pain and shock

Treatment of hæmorrhage, blood transfusion or infusion

Catheter or puncture of bladder

### **3 Main Dressing Station 6-30 km behind the Line —**

Personnel 1 C O

2 surgeons (1 specialist)

1 medical specialist

1 dentist

40 other ranks

Minimum accommodation 130

Tracheotomy, suture of open pneumothorax, primary amputations, ligature of vessels, transfusions, surgical treatment to make fit for evacuation

### **4 Field Hospital 30-70 km behind the Line —**

Personnel 1 C O

1 surgeon

1 medical specialist

3 G D officers

88 other ranks

250 beds, but, as a rule, 500-600 patients

Surgical treatment, brain surgical treatment, chest wounds, abdominal, joints, fractures, and vessel wounds

### **5 Base Hospital —**

Surgical treatment of all wounds with all specialists

For the treatment of light cases there were established Field dressing stations near the line

In Italy each army had one Field hospital which had all specialists as at Base hospitals

## DISCUSSION

It is evident that the orthodox German surgical policy was on the whole sound and corresponded in many ways with that of the British Army up to 1942, apart from continental variations

The Feldlazarett or Field Hospital may be described as the keystone of the German Surgical Service It can be compared with the C C S of the 1914-18 war, the Mobile C C S of the earlier days of Eighth Army, or the Field Dressing Station, converted into an 'advanced surgical centre' by the addition of surgical and transfusion units, of the later stages of the Italian campaign, in each of these the majority of primary surgical operations being performed The equipment of the Feldlazarett was good and it was possible with it to maintain a hospital of 200 to 500 beds and provide suitable operating and X-ray facilities One such hospital during the period October, 1943, to December, 1944, admitted 9486 surgical cases—including 1480 fractures, 1184 joint lesions, 980 brain wounds, and 91 cases of appendicitis, approximately 70 per cent of each group of which required operation

By comparison, one British Field Surgical Unit might perform between 1500 and 2000 operations in one year, although in one period at a C C S 118 major operations were performed by one surgeon in six days, while an assistant surgeon, working simultaneously, operated upon over 200 minor primary wound cases

During the different stages of the war it was, of course, necessary for the duties of individual units to alter, depending on whether an advance or retreat was taking place, and on the state of the receiving or evacuating line of communication. The best conditions for treatment, rest, and evacuation on the German side were met with in static warfare and the worst in retreat. Allied air superiority in the latter stages of the campaign caused almost insuperable difficulties in evacuation, resulting in pre-operative delay and post-operative overcrowding at a hospital, such as Abano, which was placed centrally in the evacuation chain. Roads were frequently blocked, necessitating the carrying of wounded around road obstructions, or an ambulance train, unable to reach its destination, might be compelled to return its load. On the British side it can be recorded (Stammers) that "the results of delayed primary suture during the Gothic Line battle were less good than during the Cassino days and this because the lines of evacuation in September and October were very long, and in consequence the optimum time for the delayed suture was missed. As pressure of work eased off we were able to establish delayed suture centres in Army areas and were therefore able to apply delayed suture at the optimum time."

Medical supplies, such as gauze, wool and bandages, were becoming short, and Abano had become filled with patients who were intended for the Base hospitals at Merano and Cortina. Although conditions were not as good as at the Base, these excuses cannot, however, be accepted for the standard of treatment which resulted. The policy as the war progressed had been to send the younger medical orderlies with good experience to the forward units and to replace them by older men, and the former surgical specialists who had been killed or captured had been gradually replaced by recently qualified assistant surgeons or older civilian surgeons without adequate experience of war surgery. It has been suggested that many of these had a false estimate of their own powers and a lack of good judgement—certainly these accusations were fully borne out when some of the surgical work of the hospital group was examined.

Investigation of over 100 death reports, summarized and translated into English, showed that the majority of patients reached the surgeon within one day of wounding. Their operations and subsequent dressings could not possibly have been carried out according to the official instructions and this will be clear after reading the description of the state of both wounds and patients.

Failure in asepsis cannot be excused on the grounds of overwork, bad accommodation, or inexperience. On certain necessary occasions one

has maintained a practical standard of asepsis in an underground wine cellar using a simple lamp, a stretcher as operating table, water from a 'jerrycan' and only that amount of theatre equipment which could be carried by some of the C.C.S. staff in the twelve theatre 'landing packs' which were available.

Pressure of admissions has never forced us materially to lower our standards either in forward units or at the Base, and it will be remembered that many of our surgeons also were similarly recently qualified. From personal observation of the cases arriving at a desert hospital during the Battle of Alamein it can confidently be stated that the standard of treatment and surgical handicraft, even before penicillin and delayed suture were adopted, were much higher than those met in Abano some three years later.

Admittedly, a part of the success of British War Surgery can be attributed to the correct use of penicillin, to blood transfusion, to the policy of having facilities for good surgery and post-operative nursing in the forward areas, and to delayed suture. But it is also true that it is only an adaptable surgical service, working with the active assistance of its policy by the administrative commanders, which can enable the necessary research into, and trial and adoption of, these adjuncts to the essential excision operation to be made.

Adaptability has long been the keystone in the training of the British Army, and the conditions at Abano Terme provided us with a valuable lesson in the results of the neglect of this teaching.

"Trotz starker Kreislaufmittel tritt der exitus letalis ein."

## SUMMARY

1 The state of the Abano Terme Hospital Centre in May, 1945, and certain aspects of the policy which gave rise to this are described.

2 Notes are given on the orthodox policy in German War Surgery.

3 The differences between the German and British methods are discussed.

We are much indebted to the Specialist Consultants for their advice, and to our colleagues of the British Cadre for their help and co-operation. Our thanks are due to Brigadier W. M. Cameron, O.B.E., D.D.M.S., Eighth Army, and to Brigadier H. C. Edwards, C.B.E., Consulting Surgeon, A.F.H.Q., for permission to publish this article.

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# EXPERIMENTAL OBSERVATIONS ON THE USE OF ABSORBABLE AND NON-ABSORBABLE PLASTICS IN BONE SURGERY

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Two main classes of materials have been employed in the course of this experimental investigation (1) Non-protein plastics of varying origin and composition, (2) Protein plastics

1 *Non-protein Plastics*—The chief plastics of this class that have been studied are methyl methacrylate (Perspex), cellulose acetate, Nylon, urea, and phenolics. Experimentally, methyl methacrylate proved to have the most satisfactory characteristics and, in the later work, it alone was studied in detail from the point of view of surgical applicability. The properties and possible uses of methyl methacrylate plastic will be considered later

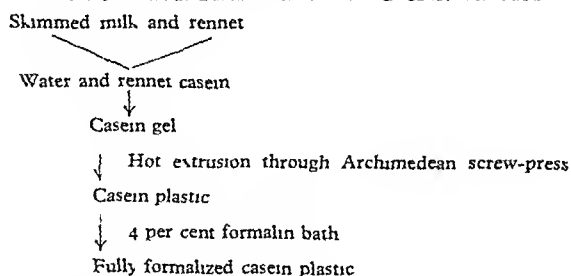
2 *Protein Plastics*—The chief protein plastics studied were made up from casein, fibrin, casein with plasma, red blood-cells, and whole blood. These proteins resemble one another in their physical and physiological properties, differing only in their quantitative characters. The protein plastic chiefly studied was casein plastic

One fundamental and surgically important difference was established between the non-protein and the protein plastics. The non-protein plastics are not absorbable in animal tissues, the protein plastics on the contrary are absorbable, the rate of absorption depending on various factors. It is proposed to consider first in detail the protein plastics

## PROTEIN PLASTICS

**Preparation and Properties of Protein Plastics**—Table I shows in outline the method of preparation of casein plastic. The same general procedure with appropriate modifications is employed for the other protein plastics

Table I—THE PREPARATION OF CASEIN PLASTIC



Skimmed milk is treated with rennet, casein is precipitated. The dry casein powder is treated with water and converted into a gel in a mixing machine, from which it is extruded along a heated Archimedeian screw-press under pressure, thus being converted into a plastic. At this stage the material

is rubbery in consistency and easily mouldable, if plunged into cold water it becomes rigid and so retains the shape previously imposed upon it. This so-called initial or 'unformalized' plastic is of limited strength, brittle, and subject to putrefactive change. It is, therefore, commercially treated by immersion in a 4 per cent formalin bath. The formalin slowly penetrates the plastic mass from the surface, advancing at the rate of about 1 mm per 14 days. The formalin unites with the casein to form a condensation product. The formalized plastic is stronger than the unformalized (by up to 30 per cent) and is no longer subject to putrefaction. Material in which the formalin has penetrated the entire mass of the plastic is called fully formalized plastic. In this research, both plastics formalized for periods of 1 to 14 days and fully formalized plastics have been employed. These plastics can be machined to provide screws, plates, blocks (that might be used as grafts), triffin nails, and other objects.

It must be emphasized that the strength of these protein plastics is not in the same class as the metals. Their strength, however, is of the same order as that of bone. Strength, as stated, increases with the degree of formalization, it decreases, however, if the material is stored under unsatisfactory conditions. The best conditions are at comfortable room temperature and at a relative humidity of 75 per cent. In airtight containers, the plastic will remain unaltered indefinitely.

**Fate of Protein Plastics in the Animal Body**—As will be explained in detail, the protein plastics are in time completely absorbed in the tissues, giving rise to little if any permanent fibrous tissue reaction. The speed of absorption depends on—

- 1 The degree of formalization, fully formalized material being the slowest
- 2 The bulk of the implant
- 3 The tissue in which it is placed. Thus absorption is (perhaps surprisingly) faster in bone than in skeletal muscle

When a protein plastic is implanted in a tissue, a series of changes regularly takes place. These changes can be illustrated by experiments in which a casein horseshoe was moulded around two-thirds the circumference of the shaft of the femur in rabbits. The animals were killed at intervals to enable the conditions of the casein plastic to be studied. The sequence of events is as follows. At 2 months the fully formalized protein plastic is hard and rubbery, at this stage it can be cut with a knife with difficulty. It then becomes progressively softer and cuts with increasing ease. At 4-5 months the surface, instead of being homogeneous, is granular and cheesy in appearance. It then becomes quite soft and breaks up into granular particles in a semi-liquid matrix. Finally, the entire plastic becomes mucoidal, then more fluid,

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† Work carried out while member of Staff Research Pool, Directorate of Biological Research, War Office

‡ Preliminary report, G Blum, *Proc R Soc Med*, 1945, 38, 169

and finally (at about 6 months) it completely disappears as a result of absorption. A capsule of fibrous tissue is formed in the course of absorption and at an intermediate stage may be fairly thick. Usually, however, when the plastic has disappeared the fibrous reaction is found to be greatly diminished.

In a number of experiments some periosteal reaction occurred in the vicinity of the plastic, consisting of the development of slight spurs above and below the plastic. Sometimes after the plastic was fully absorbed, the periosteal changes cleared up completely.

With partially formalized plastic these changes developed more rapidly. Thus, at 2 months such plates might be found to be quite soft, in an advanced stage of disintegration, and lying in a pool of serous fluid containing remnants of softened plastic which had broken away from the main mass. A variable degree of fibrous reaction is present at this stage.

The fate of protein plastics inserted into bone was also studied. Rabbits and cats were employed. Screws made of various materials were inserted tightly into drill holes prepared in the shaft of the tibia. In some experiments, screws of protein and non-protein origin were inserted into the same bone for purposes of comparison. The bones were X-rayed at intervals and the animals killed after varying periods to enable detailed studies to be made of the screws and bone. After external inspection, the bones were split longitudinally, photographs and coloured drawings were made and, in some cases, microscopical sections were prepared.

It was found that the protein plastic screws were completely absorbed in 4 to 6 months. It must be emphasized that the screws were of a size suitable for use on the tibia of a cat or rabbit. The very much bulkier screws which would have to be employed in clinical trials might take a longer, or much longer, time to disappear. This, however, might not prove a disadvantage.

The X-ray appearances will first be dealt with. In examining the X-ray plates it is important to remember that all the plastic materials employed are *radiolucent*, though to a varying extent.

Fig 280 shows the changes observed in the tibia of a cat in which two non-protein and one protein

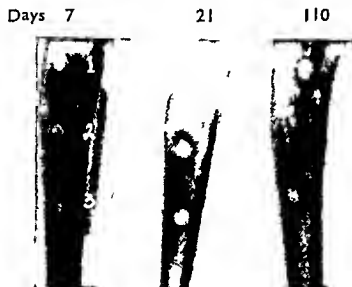


FIG 280—Radiographs of tibia of cat. Three drill holes were prepared and into them were screwed: (1) Non absorbable (cellulose acetate) plastic screw; (2) Fibrin plastic screw; (3) Phenolic plastic screw. Screw (2) had disappeared at 110 days, the others were unaffected.

plastic screws were inserted. No changes were visible at 7 or 21 days. After 110 days, however, the drill hole containing the protein plastic screw was almost completely replaced by bone, the main

mass of the screw having been absorbed. There was no sign of the protein plastic screw at 167 days. The animal was then killed and at dissection the hole was found to be substantially filled with hard bone, and there was only a tiny fragment of the plastic visible in the marrow. The non-protein plastic screws had undergone no change.

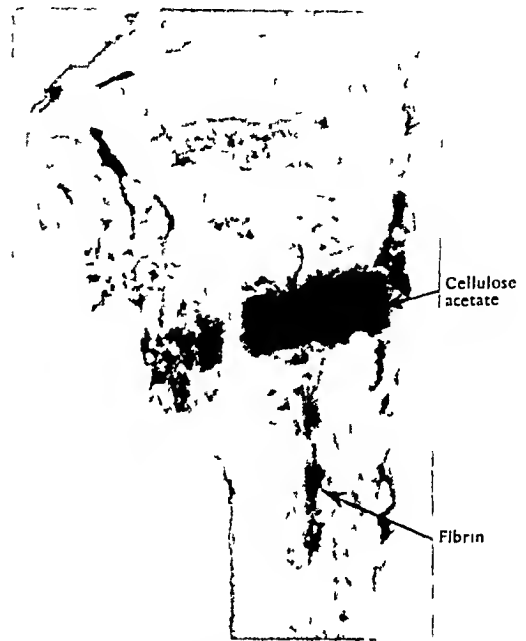


FIG 281—Longitudinally split tibia of cat 167 days after operation in which cellulose acetate and fibrin plastic screws were inserted. The cellulose acetate screw is unchanged. The drill hole originally occupied by the fibrin screw has been filled up by normal bone, some remnants are still visible in the marrow cavity.

The appearance at dissection at 167 days of the bone from a similar experiment is shown in a longitudinal section in Fig 281. The upper non-protein plastic screw has undergone no change, though there is some marginal reaction round it. The fibrin plastic screw is represented by small fragments only and its original position has been filled by bony tissue.

Fig 282 illustrates the appearance found in another animal after 167 days. The casein screw has almost completely vanished except for a small remnant in the marrow, and the drill hole has been completely filled by bone. The methyl methacrylate and urea formaldehyde screws are quite unaltered, the former especially showing its thread perfectly. There is no obvious reaction around these screws.

At dissection the changes undergone by fully formalized casein screws in bone are found to be as follows. At 1 month the screw is still fairly hard, but is becoming more elastic and rubbery; it is firmly held in the bone. At 2 months the screw is still firmly lodged, but is more easily bent. There is no bony encroachment. At 4 months the screw is still homogeneous and intact, but is very malleable. There is still little bony encroachment. At 6 months traces of disintegrating plastic are still visible, but in the main the original drill hole is filled up with



new bone No rarefaction takes place in the bone around the screw The replacement of the screw by fresh bone follows closely on the progressive dissolution and disappearance of the screw

In the case of partially formalized screws, the changes are similar in character, but occur considerably more rapidly Thus at 2 months the screw

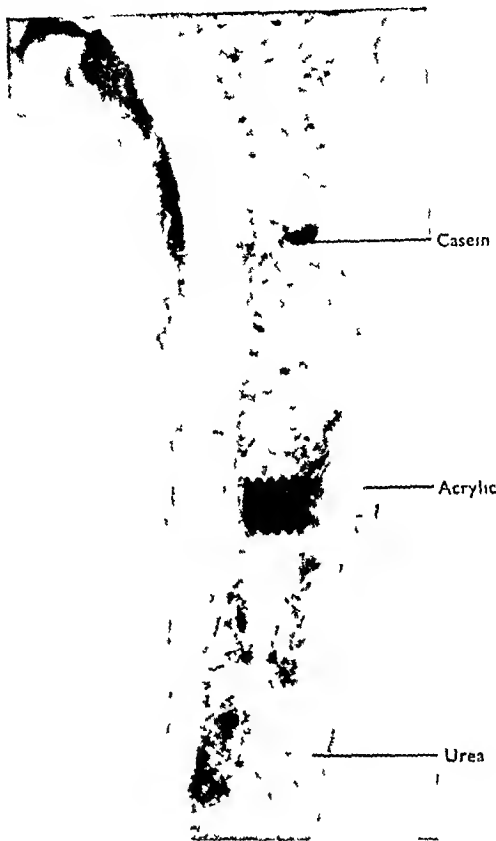


FIG 282—Longitudinal section of tibia of cat 167 days after insertion into drill holes of the following plastic screws from above downwards (1) Casein, (2) Methyl methacrylate, (3) Urea formaldehyde

may be quite soft and bony encroachment has already occurred At 3 months the screw is disintegrated and the remnants are very soft, bone proliferation is proceeding actively The speed of absorption of the protein plastics in bone is in inverse ratio to the degree of formalization

In another experiment a study was made of the fate of three casein screws, one formalized for 24 hours, one for 7 days, and one fully formalized After 3 months the 24-hours formalized screw had almost completely disappeared The fully formalized screw was rubbery in consistency, but almost intact, the 7-days formalized screw was softer and already somewhat encroached upon Similar differences can be seen in the specimen from a tibia after 2 months (Fig 283) The thread on the surface of the fully formalized screw can be readily made out, in the 7-days formalized screw the thread is no longer visible and the margins of the screw are undergoing erosion

The initial changes in consistency and tensile strength of the protein plastic may be due largely, if not wholly, to physical factors If casein or other

protein plastics are kept immersed in saline at 37° C or suspended in sealed test-tubes above water in an atmosphere saturated with water vapour at 37° C they become malleable and easily breakable after a period of one to several weeks It is likely that the further softening and ultimate disintegration and liquefaction that occurs in the body is due to the action of proteolytic enzymes which break down the casein or fibrin of the plastic into the usual soluble simpler derivatives such as peptones, polypeptides, or amino-acids These products may be responsible for the heavy cellular infiltration commonly noted at an intermediate stage at the margins

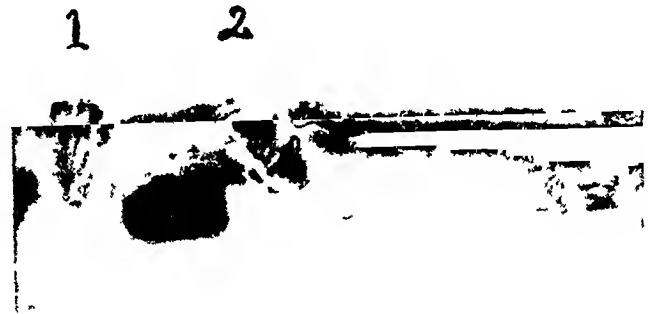


Fig 283—Longitudinal section of tibia of cat 2 months after inserting formalized casein plastic screws into drill hole The screws are split in their long axis 1, Fully formalized, 2, 7 days formalized

of the softened plastic, ultimately, however, the plastic does completely disappear and in bone the plastic is replaced by bony tissue

**Non-toxicity of Protein Plastics**—The most sensitive index of tissue response to foreign bodies is the effect produced by the substance on explants of embryonic tissues Miss Honor Fell (of the Strangeways Laboratory) kindly carried out such tests, the results of which are seen in Table II

Table II—EFFECT OF ABSORBABLE PLASTICS ON EMBRYONIC EXPLANTS OF TISSUE

SUBSTANCE (3 PLATES OF EACH)	24-HOUR RESULT	48-HOUR RESULT
1 Fibrin plastic	Good growth	Growing well bits of plastic incorporated in tissue
2 Casein plastic	Fair growth	Same as in 1
3 Fibrinogen plastic	Fair growth	Same as in 1 and 2

The tests were carried out with the plastics in granular form, the casein plastic examined was fully formalized It is clear that none of these protein plastics has any harmful effect on these highly delicate proliferating embryonic explants

The protein plastics employed can be satisfactorily sterilized by autoclaving for 20 minutes at 15 lb pressure at 120° C They must, however, be dried and cooled to maintain their tensile strength

The results so far recorded can be summarized thus —

1 The protein plastics employed are not harmful to tissues



2 The protein plastics are completely absorbed in soft tissues and in bone

3 The protein plastics inserted in bone are completely replaced by new bone

As these are protein plastics, one has to bear in mind the possibility of sensitization developing. No evidence of allergy has been obtained in animal experiments. In some animals protein plastics have been inserted on several occasions in the same animal without harm.

The question arises whether these absorbable plastics have any field of usefulness clinically. The observations in experimental animals suggest that no great risks would be involved in carrying out clinical trials by using 'hard' protein plastics in bone surgery. The protein plastics suffer, however, from one serious disadvantage which will have to be overcome before they can be employed in any position where they are subjected to significant strain, this disability is the rapidity with which they undergo softening and loss of tensile strength when exposed to moisture at a temperature of 37° C. As already mentioned, specimens immersed in saline at 37° C or suspended over water at the same temperature, in sealed tubes generally began to soften in 10-14 days. There was a good deal of variability in the changes shown by different batches of the plastic, but even the most resistant began to soften in about 4 weeks. Resistance to moisture and to other destructive agents, however, has been shown to be enhanced by increased formalization. It may be possible in the near future to subject screws or plates to a process of case hardening or other form of treatment which may enable them to retain their original physical properties for longer periods. If the protein plastics could be treated so as to remain substantially unaltered in physical properties in the body for about 3 months before they undergo the disintegrative changes already described, their field of clinical usefulness might be extensive.

### NON-PROTEIN PLASTICS

As already mentioned, prolonged experiments up to periods of 9 months showed that plastics derived from non-protein sources are not changed and, therefore, are not absorbed in the soft tissues or in bone. Individual compounds vary in the degree of tissue response which they produce. Experiments by Miss Fell (*Table III*) on embryonic explants show that some of them kill this delicate tissue. Methyl methacrylate tested in this way produced no deleterious effects.

In a general way, the gross responses of animal tissues to the presence of these plastics agree with the findings of Miss Fell. Methyl methacrylate plastic is well tolerated by the tissues and often produces little or no fibrous reaction. Frequently even the plastics which are most lethal to tissue cultures produce little gross tissue reaction. Thus, for instance, urea plastics were well tolerated in tissues and also showed a bacteriostatic effect *in vitro*. The tissue response found to the plastics investigated has been recently confirmed by Bailey, Hawn, and Ford (1943), and Ferry and Morrison (1944), both teams of workers investigated plastics, especially protein plastics, for their possible use in other fields of surgery (e.g., brain surgery). They also

found protein that plastics were absorbable. Bailey, Hawn, and Ford recorded tissue reaction in the presence of methyl methacrylate, Nylon, and vinyls.

**Methyl Methacrylate**—In view of Miss Fell's findings, and also for certain physical reasons, methyl methacrylate was selected for more prolonged and detailed experimental study. This plastic is derived from acetone-cyanhydrine by a complex series of reactions. Pressure-polymerized methyl methacrylate (Perspex) is perhaps stronger than protein plastics, but is not comparable in

*Table III*—EFFECT OF NON-ABSORBABLE PLASTICS ON EMBRYONIC EXPLANTS OF TISSUE

SUBSTANCE (3 PLATES OF EACH)	24 HOUR RESULT	48 HOUR RESULT
1 Urea (and formaldehyde)	No growth	Dead
2 Phenol (and formaldehyde)	Fair growth	Growing well Bits of plastic incorporated in tissue
3 Cellulose acetate	2 no growth 1 fair growth	2 dead, 1 poor sick, out-growth
4 Methyl methacrylate	Fair growth	Growing well
5 Nylon	Fair growth	Growing well
6 Steel	Fair growth	Not very good, 2 have (?) cellulose acetate fragments incorporated
7 Control	Fair growth	Normal

strength with steel. A long series of experiments was carried out using methyl methacrylate plates, tubes, and screws in the treatment of fractures in experimental animals. On the whole, the results suggest that this (or any other non-absorbable) plastic used in this manner has no outstanding advantages over the metals and has the disadvantage of being a much weaker material.

Methyl methacrylate is characterized by the variety of ways in which polymerization can be attained. By the use of plasticizers, its physical properties can be changed and thus, for instance, 'inhibited' methyl methacrylate will polymerize into a flexible sheet instead of into a hard sheet. Polymerization to produce a hard plastic can be carried out with either of the following techniques—

1 Pressure and heat polymerization by 'injection moulding'. This is the process leading to the formation of 'Perspex' sheets commonly used in aircraft construction.

2 Mixing the monomer and polymer in correct proportions to form a dough. (a) With pressure and heat a similar product to that in (1) is obtained, (b) Without pressure and heat, a plastic of granular appearance is obtained which is much weaker than the pressure-heat product.

3 Addition of a catalyst (benzoyl peroxide, benzoin) to the monomer turns the liquid monomer into a final product akin to the one described in (1). When heated on a waterbath at 50° C, this result can be attained in 2-4 hours. If the monomer is allowed to stand at room temperature, the process may take up to 1-2 weeks. The concentration of the catalyst determines the speed of the polymerization.

Methyl methacrylate is being widely used clinically at present for different purposes. Thus it is being employed in the manufacture of dental baseplates, artificial teeth, and dental fillings, for Gunning splints used in the treatment of fractures of the mandible in edentulous patients and for the filling of gaps in the cranium and in facial bones. The technique at present employed for all these purposes is a lengthy one. For example, in preparing an obturator cap for a skull defect the following steps are necessary: an impression is taken of the defect, the impression is then cast, a wax replica is prepared which is transferred to a dental flask where the wax is replaced by methyl methacrylate dough and polymerized under heat and pressure. These steps take 2-2½ hours in the hands of an experienced dental technician. The cap has to pass through a final finishing process before it is ready for use. Its insertion into the gap therefore involves a second operation. This, incidentally, is also the case with tantalum, a new alloy now widely used in brain surgery for the filling of bony gaps (the high cost of tantalum is another factor to take into consideration).

Methods have, therefore, been adopted which enable methyl methacrylate to be used for these and other purposes in a much shorter time, of the order of 15-20 minutes. If such procedures were employed, for example, in the filling of bony gaps they would enable the operative treatment to be completed in one sitting. The methods recommended will now be described.

1 *Moulding of Sheet Material*—Fully polymerized methyl methacrylate sheet, when heated to 130°C, becomes readily mouldable and soft to handle. Pressed to a model it takes the exact shape of the 'master' and retains this acquired shape if rapidly cooled. The details of this method are as follows—

a An impression is taken of the bony defect with a sterile impression material, such as Zelex. The impression material, carried in a tray, is in the form of a thick paste when pressed into the gap, after 2-3 minutes contact, it becomes hard and shows the exact "negative" of the contour.

b Sterile plaster-of-Paris (which has been worked into a paste) is now poured into this negative mould. This sets in about 5 min and thus provides a "positive" model of the gap.

c This model is now transferred to a hand-press. The tray carrying it fits into the base of the press, into the upper moving platform of which is inserted a cylinder filled with sorbo rubber.

d A sheet of plastic of the required size is meanwhile heated on a heating plate. Exposure to 130°C for 1-2 minutes is sufficient to make it soft and rubbery.

e The plastic is now transferred to cover the model and the cylinder filled with sorbo rubber is quickly pressed home. Pressure is kept up for about 2-3 minutes, which is sufficient to allow the plastic to cool and retain its acquired shape.

If the above procedure is carried out under aseptic conditions it is unnecessary to sterilize the prosthesis further. If heat sterilization, however, is decided on, it is important to remember that only unplasticized, pure methyl methacrylate sheet will withstand sterilization by boiling or autoclaving.

Plasticized sheet undergoes deformation at about 80°C and thus loses its acquired shape. Therefore, unplasticized sheet must be employed if heat sterilization of the final product is to be carried out.

The advantages of this method are clear. It allows fitting of a good prosthetic plate in a reasonable time, making a second operation unnecessary, and thus also reducing the period of hospitalization.

2 *Use of a 'Light Accelerated' Monomer*—As previously mentioned, one of the techniques of the polymerization of this plastic depends on the conversion of the monomer (with catalyst) into a polymerization product. Another technique described was the mixture of monomer and polymer into a dough. With either of these two methods the speed of final hardening depends on heat, pressure, and the proportion of ingredients. Thus, for instance, a 1:4 monomer and polymer dough, inserted into animal tissue as a paste, will harden up completely in 24 hours.

Light of 3250 Angstrom units (ultra-violet light) acts on a dough of monomer (containing 2 per cent benzoin) and very finely ground polymer in the proportion of 1:4 as a very potent accelerator of the reaction. Polymerization is attained in about 15 minutes. The temperature at which this polymerization takes place is under body temperature, its optimum is about 85°F at a focus of about 4-5 in. Slight variations in time of polymerization must be allowed for, depending on the size and thickness of the area to be hardened.

A series of experiments on cats and rabbits was undertaken to test the tissue reaction to this procedure. The dough was inserted into skull gaps and also around the exposed and roughened laminae and spinous processes of the dorsal spine. No unfavourable tissue reaction occurred. In the skull-gap experiment there was no dural reaction, the underlying brain was normal, some ossification took place across the floor of the gap between the plastic and the dura. In spinal fixation the bony and soft tissues looked perfectly normal after 3 months.

This method might be of particular interest to the plastic surgeon. The filling of bony gaps and defects in the face, especially when the gap is not a whole-depth gap might be worth considering. The use of methyl methacrylate dough in arthrodesis (either by the accelerated or delayed method) may also be worth a trial.

## SUMMARY

1 The behaviour of non-absorbable (non-protein) and absorbable (protein) plastics in animal tissues has been studied.

2 Protein plastics are fully absorbable in tissues without causing unsatisfactory tissue reactions. In bone the protein plastics are replaced by bone.

3 The possible clinical uses of protein plastics in bone surgery are considered.

4 Out of a number of non-absorbable (non-protein) plastics tested methyl methacrylate was found to be most satisfactory from the point of view of possible clinical use in bone surgery.

5 Two methods of using this plastic are described. (a) A rapid moulding technique of acrylic sheet, and (b) Rapid polymerization by

ultra-violet-ray acceleration Their usefulness in bone surgery is outlined Both methods allow the plastic to be used at the time of the first operation, making a second operation for their insertion superfluous

My thanks are due to Professor Samson Wright, in whose department and under whose supervision this work was carried out, to Major-General D C Munro, Consulting Surgeon to the Army, Brigadier W Rowley Bristow, Consulting Orthopaedic Surgeon to the Army, and Brigadier F A E Crew, Director of Biological Research, War Office, for permission to carry out the work, to Ernoid Ltd, and the Medical Supply Association for a grant to cover technical expenditure (as authorized by the M R C and the War Office), and much valuable assistance

in the provision of protein plastics and accessories, to Imperial Chemical Industries, Plastics Division, for advice and supply of acrylics, to Dr C A Redfarn, Consultant in Plastics Chemistry, for much information about plastics, and to my staff, L/Cpls P Hodgkins and F Lawton, and V A D Cpl M M E East, for technical assistance

The cost of the animal experiments and other expenses were defrayed from a grant made by the Medical Research Council

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## INTERESTING CERVICAL TUMOURS\*

### A REPORT OF THREE CASES

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THE following cases of cervical tumour are, I believe, of sufficient interest to warrant their recording. They each present features which are somewhat uncommon

#### CASE REPORTS

**Case 1**—John McR, aged 55 years, was admitted to the Royal Infirmary, Edinburgh, on March 22, 1944, complaining of a swelling on the left side of his neck.

**HISTORY**—During the summer of last year, towards the latter half of July, he found that his collars were becoming too tight and he noticed that a swelling had developed on the left side of his neck. It was quite painless. He had no other symptoms.

On reporting to his doctor, he was referred to the hospital in his home town, where a biopsy was performed. He was subsequently treated with X rays, and the swelling disappeared. Towards the end of February, 1944, he again noticed a swelling in the neck, at the original site, which seemed to him to be bigger than previously, and on this occasion his doctor referred him to the Royal Infirmary, Edinburgh.

**ON EXAMINATION**—There was a large, firm, solid swelling on the left side of the neck in the anterior triangle, lifting up the sternomastoid muscle and displacing it backwards. It was fairly smooth to feel, appeared to extend deeply, and to be relatively fixed. Its outline could not be defined. The skin over the swelling was slightly reddened and seemed to be fixed to the tumour. There were no other features, no change in voice, no dysphagia, no dyspnoea, no irritation of the throat. Cardiovascular and respiratory systems were normal.

At this time we had no report of the result of the biopsy done previously, and in view of the fact that he had also had X-ray therapy, it was decided to do a second biopsy in order to determine the nature of the swelling. This was done soon after admission, three or four small pieces of tumour tissue being snipped off through an inch-long incision. The pathologist in the Department of Clinical Surgery reported as follows—

**Microscopical Sections** “The sections show the tumour to be composed of groups of cells, somewhat epithelioid in appearance. The most striking feature is the sinusoidal arrangement of the blood-vessels and the fact that the sinus cells are separated from the blood by the endothelium of the sinuses only, without the intervention of adventitious tissue. The appearances are suggestive of a carotid body tumour.”

Two or three days later we received information from the hospital where he had first been treated by biopsy and deep X-ray therapy. They informed us that at the original operation, although the tumour was not fixed to the skin or underlying tissues, it was found to encircle closely the carotid vessels, and total removal was not possible, a part, therefore, was removed for examination.

Pathological examination showed what seemed to be a secondary carcinoma invading the tissues, the cells being cubical and columnar, suggesting origin in a mucous surface.

An examination of the larynx and pharynx was done, and there was seen to be a thickening in the region of the left arytenoid, with oedema and an appearance suggestive of new growth in the lateral wall of the pharynx immediately above this. Under direct laryngoscopy a biopsy was performed, the sections of which were reported as being ‘anaplastic squamous epithelioma’.

He was treated by deep X-ray therapy, being given maximum dosage, and suffered a fairly severe reaction. The swelling on the left side of the neck disappeared, and in January, 1944, he seemed quite fit.

After receiving this information we had him examined in the Ear, Nose, and Throat Department. The report was as follows: “On examination there is a want of movement of the left arytenoid, with a large polypoidal mass overhanging the arytenoid. Whether this is coming from the arytenoid itself, or from the lateral wall of the pharynx, is difficult to say. We are arranging to examine him with a laryngoscope.”

The photographs reproduced here (Fig 284, A, B) were taken on April 14. The tumour has fungated through the biopsy scar.

Something had to be done for the patient, and operative removal being out of the question, and also further

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deep X-ray therapy being thought inadvisable on account of the dosage previously employed, it was decided, in consultation with the radiologist, to implant radium needles

Shortly afterwards laryngoscopic examination was carried out, and on this occasion the finding was as follows "On examination there is a curious œdema of the posterior pharyngeal wall, limited to the left side. This goes right down the left lateral pharynx, and the left pyriform sinus is œdematous. There is a marked œdema of the posterior wall at the level of the tip of the left arytenoid which obliterates the view of the larynx, but on pushing this aside it is noted that the œdema extends along the left false cord. The left arytenoid is moving, though not so well as the right. The cords are almost normal and the trachea is normal with normal tracheal rings. There is no suggestion of any ulceration in the nasopharynx or hypopharynx."

In a personal communication the ear, nose, and throat surgeon stated that in his opinion the œdema was entirely due to lymphatic blockage.

On June 13 the patient was discharged to the convalescent home. The tumour mass seen in Fig 284, A, B had entirely disappeared, leaving a round hole about the size of a sixpence, with a sloughing base.

He remained quite well for about three weeks, when he was readmitted following a severe hæmorrhage from the wound. This ceased, but his general condition rapidly deteriorated, and he finally died on July 29, almost exactly four months after admission. Autopsy was refused.

**Discussion**—Microscopical examination of the tissue removed by us indicated that this was a carotid-body tumour. Figs 285, 286 show the appearance

According to Hertzler (1937) "The gland is made up of polyhedral cells lying in juxtaposition and forming alveolar-like groups without intervening

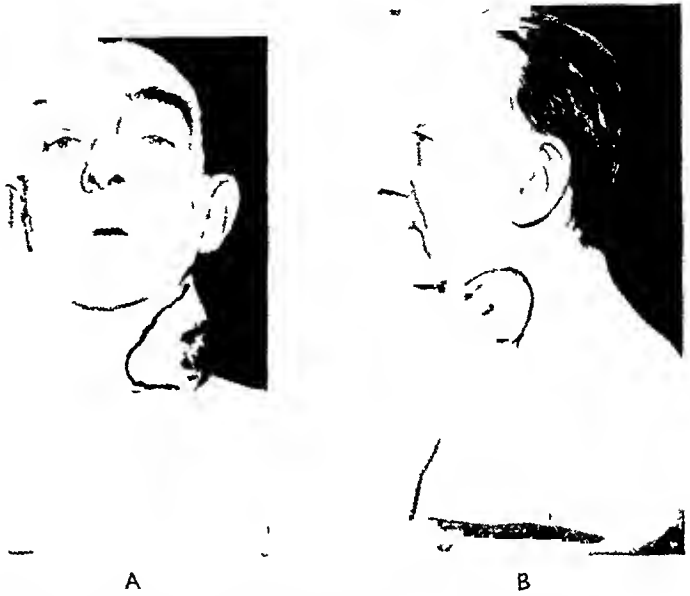


FIG 284—A, The growth is outlined showing the extension anteriorly. It has fungated through the biopsy scar. B, Shows the extent posteriorly (outlined).

connective tissue. The cells lie in contact with blood-vessels or blood-sinuses."

The photomicrographs reproduced show these features. The appearance is very like carotid-body tumour. To quote Hertzler again "A photomicrograph should be published for the benefit of



FIG 285—Case 1. Note the groups of epithelioid-like cells, separated by wide blood-sinuses ( $\times 100$ ).

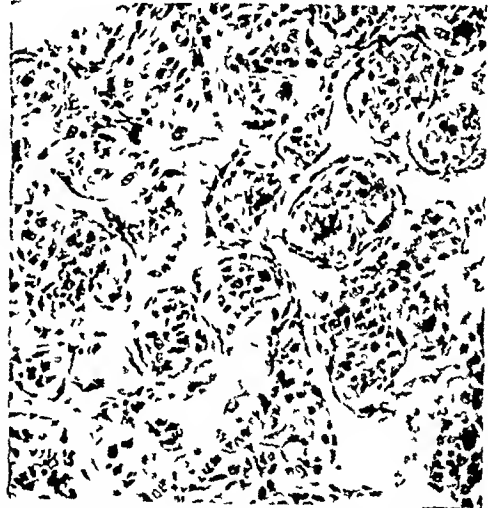


FIG 286—Same case. High-power view, showing the endothelial lining of the sinuses only between the cells and the blood-spaces. The cells are polyhedral with granular cytoplasm ( $\times 400$ ).

It is that which is typically described as being the picture of carotid-body tumour—"The common appearance is that of masses of polyhedral granular cells. The blood-vessels, in the form of sinuses, may be very numerous, and give the tumour a hæmangiomatous appearance" (Illingworth and Dick, 1938).

sceptics if the tumour is reported in the literature as a carotid-body tumour."

Compare Fig 255 with the photomicrograph on p 98 of Hertzler's monograph. The similarity is exceedingly striking.

When, a few days later, the patient was again examined in the ENT Department, and it was

found that the swelling, previously reported as a polypoid mass, and thought to be a primary pharyngeal tumour, was the swelling of œdema, and the arytenoid, pharyngeal wall, etc., showed no evidence of true tumour, we felt more certain of our diagnosis. The laryngologist stated that he considered the œdema to be due to lymphatic blockage, and in view of the extensive infiltration of the tumour this seemed a reasonable explanation.

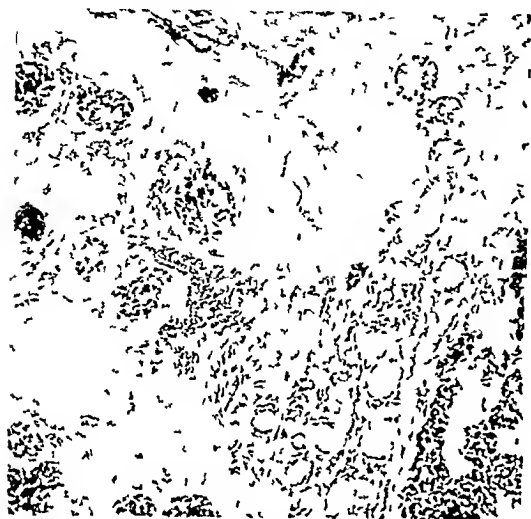


FIG 287—Same case. In the lower half of the photomicrograph can be seen normal racemose glands. Above and to the right is seen hyperplasia of the lining epithelium, with cells erupting through the basement membrane. Above and to the left are groups of frankly malignant cells lying free in the stroma ( $\times 70$ ).

A second pathological opinion was sought, and the slide was reported as being 'suggestive' of carotid-body tumour, but attention was drawn to the large number of mitotic figures present, an unusual feature of this type of neoplasm, which, of course, is relatively benign, although occasionally marked evidence of malignancy is seen, as described by H. H. Stewart (1931).

On receiving information from the patient's own hospital that a biopsy done previously had shown a picture suggestive of a secondary invasive carcinoma, the cells being cuboidal and columnar in type, and also that a biopsy from the pharynx revealed a picture resembling anaplastic squamous epithelioma, we had to review our diagnosis and re-study our sections with great care, especially as the previous report was made by a pathologist whose opinion carries a great deal of weight. He very kindly cut further sections from his blocks, the slides of which are reproduced here—Fig 287 showing the tissue removed from the pharynx, and Fig 288 that removed from the neck.

Examination of these further sections enabled us to trace the origin of the tumour to the mucous glands in the wall of the pharynx, and Fig 287 shows transition from normal racemose glands to frank malignancy.

The difference between Figs 285 and 286 and 287 are quite marked. Where, then, does the explanation lie? We have two pathological reports,

quite different, made on the same tumour, and two microscopical slides showing marked differences (I would like to state here that there is no question of the slides having become mixed, and being from two different individuals).

Had we not received information from the hospital in which the patient was treated previously, we would have felt quite confident of our diagnosis of carotid-body tumour (see Figs 285, 286) and perhaps

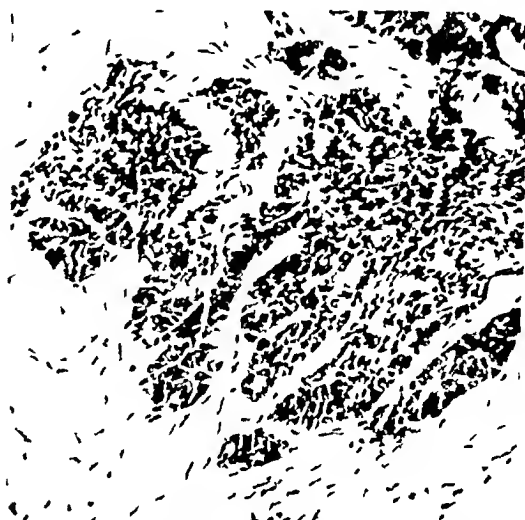


FIG 288—Same case. Tissue originally removed from neck showing glandular carcinoma with some attempt at acinar formation.

have published the case, in all good faith, as an example of that tumour.

The explanation lies, I feel, in the changes which must have occurred between cessation of treatment in the summer of 1943, coincident with the disappearance of the swelling, and the reappearance of the tumour in February of the next year. During the further growth of the tumour mass in the neck, after the effects of deep X-ray therapy had worn off, a tremendous increase in vascularity occurred, and many thin-walled blood-vessels and blood-sinuses were formed, which surrounded and separated groups of cells into spherical clusters, to produce with extraordinary exactitude the deceitful picture (Fig 285) of carotid-body tumour.

This case makes one reflect back and wonder if any case, previously thought to be a carotid-body tumour, could possibly have had some hidden origin, and a similar explanation.

**Case 2**—George P., aged 42 years, a farmer. This patient was admitted on March 29, 1944, complaining of "swelling in the right side of the neck, of five weeks' duration."

**HISTORY**—In January, 1944, the patient had severe neuritis of the right arm, worse on the dorsal aspect of the arm, and felt especially badly over the scapular region. He retired to bed and has been in bed since then. The pain was very severe, every movement being excruciating. After three weeks of this, he visited his doctor, who gave him injections of vitamin B—twelve in all. These injections did cause most of the pain to vanish. About five weeks before admission (i.e., seven weeks after onset of symptoms) he began to lose his

voice, and he was troubled with cough and a clear watery expectoration. About the same time as he began to lose his voice, he noticed a small lump on the right side of the neck, in the supraclavicular region. During the last two weeks he has had some difficulty in swallowing.

*Previous History* Nil



FIG 289—Case 2 Showing typical Horner's syndrome

ON EXAMINATION—Pulse 94 Blood-pressure 160/82. A thin, though not emaciated, man. Good colour. Healthy looking. On the right side is a typical Horner's syndrome (Fig 289). Voice is a slight whisper. In the right supraclavicular region is a firm, fixed

colour, and on incision a quantity of clear, yellowish fluid escaped. The tumour proved irremovable. A piece of the wall was removed.

Severe hæmorrhage developed, and it was found that the tumour had invaded the vertebral artery. The friable vessel wall tore with artery forceps, and a tight pack was inserted and the wound closed around.

April 7 Wound partially reopened and pack very slowly removed. No further hæmorrhage occurred.

#### **PATHOLOGICAL REPORT—**

1 Fluid from cyst. There are a small number of mononuclear cells present. No organisms. Cultures sterile.

2 Biopsy tissue. The tissue is heavily infiltrated with squamous epitheliomatous tumour growth. In places there are many well-formed cell-nests; elsewhere the tumour cells are undifferentiated. There is a well-marked fibroblastic reaction (Figs 290, 291).

**Discussion**—This case, with one exception, has a clinical picture which fits in very well with the description of a tumour occurring at the thoracic inlet known as the 'superior pulmonary sulcus tumour', or Pancoast's tumour. Pancoast (1932) described these tumours as occurring at the thoracic inlet, characterized by pain around the shoulder and down the arm, Horner's syndrome, atrophy of the muscles of the hand, and X-ray evidence of a small homogeneous shadow at the right apex, plus "always more or less local rib destruction and often vertebral infiltration."

This patient presented all these features, except the bony destruction, but this may occur late, and at present the tumour (or rather the symptoms) date only from January, 1944, a matter of four months. In Pancoast's account of his cases, I note that the rib involvement began anything from three to nine months after the onset of symptoms,



FIG 290—Same case. Showing groups of epithelial cells with a well marked fibroblastic reaction. Cell-nests are well seen ( $\times 100$ ).

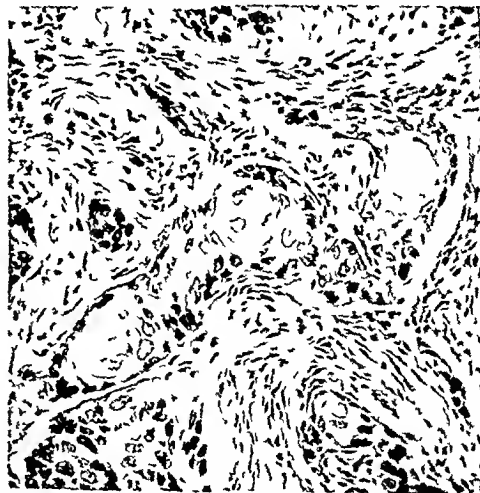


FIG 291—Same case. Squamous epithelioma showing characteristic epithelial pearls ( $\times 400$ ).

swelling, about  $1\frac{1}{2}$  in in diameter. There is wasting of the muscles of the thenar eminence of the right hand and less marked wasting of other hand muscles.

X-ray Examination (Feb 23)—"Trachea shows slight displacement to the left in the root of the neck. There is some increased soft tissue shadow to the right of the midline."

Biopsy (March 30)—On exposing the swelling in the root of the neck, it was seen to be cystic and bluish in

so the absence of involvement of bone I do not think weighs heavily against the suggested diagnosis of superior pulmonary sulcus tumour.

Histologically, the tumour is a squamous-cell epithelioma, showing typical cell-nests, a fairly dense fibrous stroma, and areas of undifferentiated cells. Pancoast suggested that these tumours might have their origin in branchial rests, similar to branchiogenic carcinoma.



Morris and Harken (1940) point out that the symptomatology associated with the superior pulmonary sulcus tumour is by no means pathognomonic, but can occur from many conditions causing lesions in the pulmonary apex, and they cite various authors, showing that the syndrome can be caused by such conditions as carcinoma of the lung, metastases from carcinoma of the stomach, from hypernephroma, tumour of the thymus, various types of apical tumour, tumours of the sympathetic cord, and advanced apical tuberculosis, among other conditions.

These two authors do maintain, however, that the superior pulmonary sulcus tumour does occur as a separate and definite clinical entity, and they support Pancoast's hypothesis that it arises from branchial rests. "In the main, the assumption of a branchial origin for the 'superior pulmonary sulcus tumour' must necessarily be founded upon evidence which, although of an indirect type, is nevertheless impressive. Given a malignant epithelial tumour, primarily in the apical region where no epithelial tissue is found normally, and granted the opportunity to exclude lung, pleura, and other local structures as a source, this assumption is not unwarranted."

In *Case 2*, with a microscopical picture of epithelioma, and a fairly extensive tumour mass eroding the vertebral artery, and yet with apparently no involvement of lung, one could agree with Pancoast that it is unlikely to be due to primary lung carcinoma, as Horner's syndrome is produced so early, and the type of cell is not so likely to be found in an apical lung lesion so far away from the larger bronchi.

Morris and Harken give the following criteria for the diagnosis of a true superior sulcus tumour—

"1 Clinical evidence of an apical tumour expressed in terms of pressure destruction effects upon adjacent nerve and osseous tissues." This effect they term Hare's syndrome, pointing out that Hare described this syndrome thirty-one years before Horner.

"2 Histological evidence of epithelioma."

"3 Pathologic evidence, based upon biopsy, operative, and post-mortem studies, which are competent to prove (a) the extrapulmonary character of the tumour, (b) its 'lack of origin from lung, pleura, ribs, or mediastinum', and (c) its primary nature as determined by especially planned methods designed to exclude all possible sources of metastatic origin."

In this case there has been no post-mortem examination, so that final and conclusive evidence is not available. Clinically, however, there is no other source. The microscopical picture fits. At operation the tumour was cystic. Pancoast suggested that these tumours might arise in branchial rests. Tumours of branchial rests are of several types. Oliver (1935) gives a very full account of branchiogenic carcinoma, and shows that few occur low in the neck, but they do occur there.

There are two predominant types—cystic and solid. *Case 2* is cystic. In Oliver's series, solid were predominant, although Ewing (1940) states that the cystic type are most common.

Crile and Kearns (1935), discussing branchiogenic carcinoma, record one case occurring near the clavicle, and also record Horner's syndrome and pain down the arm in the symptomatology. Squamous-cell carcinoma is the characteristic pathological picture. Grossly, if the origin of the tumour is a cyst, some evidence of cyst wall is found, and often yellowish, semi-solid content. In this case there was definite cyst formation, and a clear yellowish fluid content was found. Pathologically the tumour could be described as a cystic type of branchiogenic carcinoma, and one would put this down as the diagnosis, were it not for the position in the thoracic inlet.

The term "superior pulmonary sulcus tumour," referring to a definite growth, of squamous epitheliomatous type, occurring in the thoracic inlet, and furthermore which is assumed to have a branchial origin, seems to me to be unnecessarily long and confusing. Until further knowledge comes to light regarding the origin of these tumours, it would seem reasonable to regard them only as branchiogenic carcinoma, and for purposes of simplification the term 'low branchiogenic' is suggested. The addition of the simple adjective as a qualification to 'branchiogenic' gives at least an indication of position, pathology, and possible origin. The long term indicates only position.

*Case 3*—Miss W., aged 73 years, complained of swelling in the left supraclavicular region of a few months' duration.

**HISTORY**—For the last few years the patient has had pain in the left shoulder, radiating down the arm to the wrist and up to the neck. During the last few months she has noticed a swelling in the supraclavicular region on the left side, and for the last few weeks she has had the impression that the swelling was increasing in size and becoming harder.

She has no other symptoms. She eats a full diet and enjoys her food, her bowels are regular, she has no urinary symptoms.

**ON EXAMINATION**—There is a moderately hard swelling in the left supraclavicular region, measuring 2-2½ in across. It is quite painless to touch, fixed, and appears to extend far medially.

There were no other positive findings, all systems showed negative results.

**X-ray Examination**—Straight radiography shows erosion of the anterior surfaces of the transverse processes and bodies of the lower cervical vertebrae on the left side.

All other radiological and special examinations were negative.

**AT OPERATION**—It was decided to explore the swelling, and this was done in May, 1944. The mass was found to be irremovable, extending far downwards and medially, and being very fixed. It was firm but not hard in consistence, and of a whitish almost translucent colour. A piece of tumour was removed for examination and the wound closed.

Pre-operatively it was thought that the tumour would probably turn out to be a neuroma, possibly sarcomatous, originating from the sheaths of the plexus, most likely from C5 and 6. The pathological report, however, was rather surprising. The tumour was reported as a 'chordoma'. "The sections examined show the tumour to be composed of masses of cells, the characteristic feature of which is vacuolation. The nuclei are for the most part spherical. In places scattered nuclei can be seen in a mucin-like matrix. There is little intercellular substance. The appearances are those of 'chordoma'."



As the tumour was irremovable, it was decided to treat the case with deep X-ray therapy, and now, one year later, the tumour has diminished in size, although only slightly. The patient is in excellent health, eating well, putting on weight, and fully active. She states that she feels fitter than for some time past.

**Discussion**—It is now accepted that chordomas arise from remnants of the notochord—the primitive skeletal axis, and consequently are most commonly found in those situations where small nodules of notochordal tissue remain. A full description of the notochord is to be found in text-books of anatomy and embryology, but it may be convenient to give here a brief account of it.

It traverses the axis and runs upwards from the anterior border of the foramen magnum to the dorsum sellæ, stopping just behind the pituitary fossa. In its cranial course, as it runs between the cartilaginous precursors of the basi-occiput and basisphenoid, it dips ventrally and escapes from between the two parachordal cartilages and lies in the roof of the pharynx.

With the process of ossification the notochord disappears where it is enclosed in bone, and at the cranial and caudal ends of the vertebral column, where it is not so imprisoned, it usually disappears also, but it is in these sites that nodules of notochordal tissues may persist. Between the vertebral



FIG 292—Case 3. Showing erosion of the transverse processes of C 6 and 7. The erosion of the anterior surface is not well seen in this view.



FIG 293—Same case. Lateral view, showing erosion of C 7 anterior half. This picture suggests that the tumour has originated in the body and made its way out anteriorly in the first instance.

The notochord (primitive skeletal axis) is developed from the anterior end of the primitive streak. Starting as a narrow process of cells, lying between the endoderm and ectoderm, as it elongates caudally it becomes incorporated in the dorsal wall of the archenteron, of which it forms a part. At a later stage, it is evaginated from the dorsal wall of the endodermal cavity and forms a rod of cells, lying in the midline, between the ectodermal neural canal and the roof of the primitive alimentary canal.

The paraxial mesoderm, lying on each side of the neural tube and notochord, eventually surrounds both these structures, and becomes separated into segments—the forerunners of the adult vertebrae, which are formed by the union of the cranial and caudal halves of adjacent segments. The part left between two developing vertebrae ultimately is the intervertebral disc.

Eventually we have the notochord passing along the whole length of the cartilaginous vertebral column from cranial to caudal end. At the cranial end it

bodies the notochord persists as the nucleus pulposus of the intervertebral disc.

Chordoma is found, therefore, most commonly at the extremities of the vertebral column—in the sacro-coccygeal region, in the roof of the pharynx, and on the cranial aspect of the spheno-occipital area, as the notochord sometimes takes a loop upwards here as well as downwards to the pharyngeal roof (Bruce and Walmsley).

In other situations, chordoma is rare, and Bruce and McKie, in 1937, reporting 2 cases of chordoma, traced in the literature 103 cases, of which only 11 were in the intermediate part of the spine, 6 of these being in the cervical region. In 1928 Cappell reported 3 cases of chordoma of the vertebral column, 2 in the cervical region, and 1 in the dorsal region. In this paper he gives an excellent resume of chordomas in unusual situations. Harvey and Dawson, in 1941, out of a total of 240 cases, including their own and those obtained from the literature, give the following figures: Cranial 88, vertebral 30,

sacrococcygeal 122 In the case reported here the tumour is arising from the cervical region of the spine

The presence of many remnants of the notochord in the shape of the nucleus pulposus of the intervertebral discs would lead one to suppose that here lies the origin of the tumour when it occurs in the vertebral column, and Ribbert's well-known experiment of puncturing the intervertebral disc of a rabbit, with subsequent escape of the nucleus pulposus and the development of the typical physaliphorous type of tumour, would appear to support this hypothesis, it is thought now, however, that they arise in the bone rather than the disc (Harvey and Dawson) Cappell (1928) has shown conclusively in 2 cases of cervical chordoma that the tumour has originated in the affected vertebral

Histologically, one of the most striking features is the vacuolation of the cells, which may take the form of a single large vacuole (*Fig 294*), or perhaps two, displacing the nucleus to one side, giving a 'signet ring' appearance, on the other hand, there may be several smaller vacuoles giving the typical physaliphorous cell (*Fig 295*) In other parts of the tumour the cells become so distended with mucin that they finally burst, mucinous material is liberated, and there results a mucinous mass containing scattered nuclei, collapsed cells, and cell remnants This process usually occurs towards the centre of the lobule, and the gradual dissolution of the cell can be traced from the periphery centrewards

The cell nuclei are mostly oval and spherical, in some areas where there is much mucinous

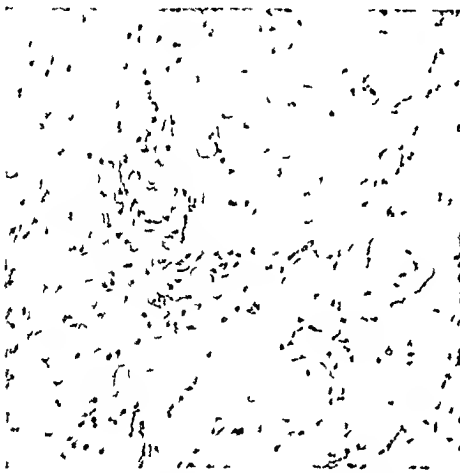


FIG 294—Case 3 Chordoma Cells showing vacuolation In the upper left-hand corner scattered nuclei are seen amidst mucinoid material ( $\times 100$ )

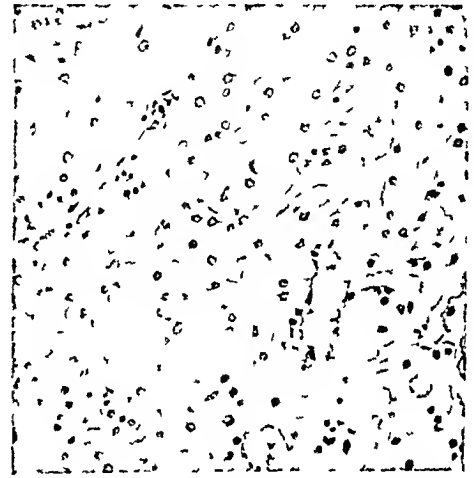


FIG 295—Same case Showing the typical physaliphorous appearance Signet-ring forms can be seen also the oval and spherical nuclei ( $\times 400$ )

body "In both of the cervical cases it is clear that the tumour has originated in the affected vertebral body or on its anterior or posterior aspect rather than in the notochordal cells which are said to persist in the centre of the intervertebral discs" Complete sections of vertebral bodies are shown, demonstrating the affection of the bone by the tumour cells, with the intervertebral discs intact The radiographs of this case (*Figs 292, 293*), especially the lateral view (*Fig 293*), show erosion and destruction of the anterior part of C 7 extending into the bone, whilst the intervertebral space maintains its integrity and the erosion is certainly not upwards or downwards through the cartilaginous plate from the space

**PATHOLOGY**—The pathological features of chordoma are now well known, they have been fully described by Cappell (1928), Stewart (1926), and Harvey and Dawson (1941), among others

The tumours are lobulated by fibrous septa—this varies in amount and sometimes is not well marked The cut surface is of a whitish translucent nature, firm but not hard, with occasional areas of hæmorrhage where degeneration has occurred There is a marked tendency to infiltrate and destroy bone

material the nuclei have a crenated shrunken appearance, and in parts the nuclei themselves can be seen to contain mucin, giving a vacuolated appearance

In their histology chordomas reproduce with a considerable degree of exactitude the stages in the development of the notochord (Cappell, 1938), from the cellular areas, simulating the appearances as seen in the early stages of the notochordal development, to the areas of intercellular mucinoid material arranged like a syncytium, representing the later stages of notochordal development and, indeed, the nucleus pulposus

**TREATMENT**—The treatment of chordoma is difficult The ideal to be aimed at is complete extirpation, but very often this is impossible, deep X-ray therapy should then be tried and in some cases (as in this one) marked benefit results, although this is likely to be of only a temporary nature, and eventually, from encroachment on vital structures, death ensues

I wish to express my thanks to Professor Sir John Fraser, Bt, for his permission to publish these cases, which were in wards under his charge

Mr D B Smith, of the Department of Clinical Surgery, has been responsible for the clinical photographs and photomicrographs, and to him also I am most grateful

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## PENETRATING WOUNDS OF THE CHEST

By W F NICHOLSON, LIEUT-COL, R A M C

THIS paper surveys 1639 penetrating chest wounds treated at a Chest Centre during the last three years. Half the period was spent in the Middle East (Nicholson and Scadding, 1944) and half in the Central Mediterranean Forces. For short periods, such as at Alexandria during the retreat to El Alamein, and at Naples at the Cassino offensive, the Centre has been so near to the front that casualties

### INCIDENCE

In summarizing the incidence of chest wounds, Carter and De Bakey (1944) state that they occur in a ratio of about one to four among those killed on the battlefield and about one to twelve among the wounded. The distribution of wounds of entry in 500 consecutive penetrating chest wounds from the

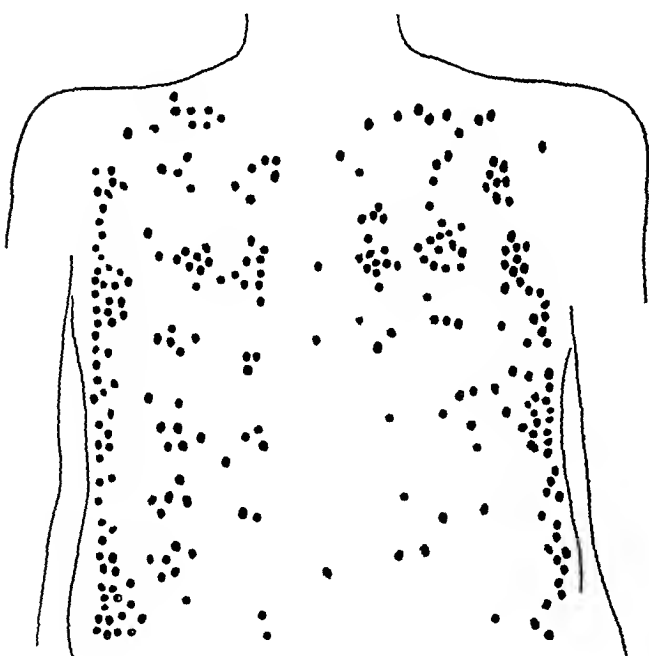


FIG 296—Entry wounds—anterior distribution

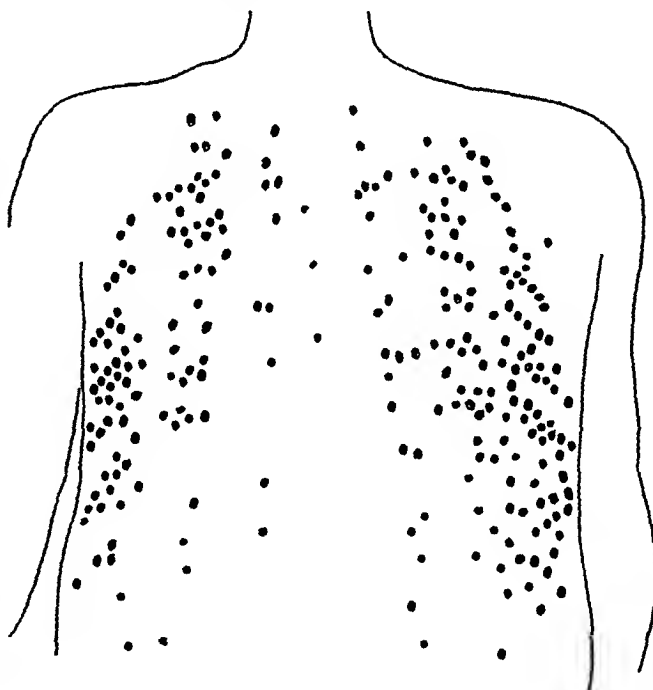


FIG 297—Entry wounds—posterior distribution

could be evacuated directly to it and the primary toilet of the wound undertaken. But more frequently they would arrive two to four days after wounding, till the battle moved away and the winter rains came, under such conditions they often did not arrive for three or four weeks. But finally the majority of penetrating wounds did reach the Chest Centre.

summer battles in Italy has been plotted, as shown in Figs 296, 297. There is a marked absence of wounds over the heart and great vessels, and relatively fewer entries in the left lower chest than in the right. The deductions are obvious, that cardiac and mediastinal wounds are often fatal, and that thoraco-abdominal wounds on the left have a higher early mortality than those on the right.

## CHARACTER OF WOUNDS

**Lung**—Some pulmonary contusion is always caused by a penetrating wound of the lung. Sometimes the path of the missile is demonstrated in a radiograph, in which it appears as a solid or air-containing track. These missile tracks, which have been well described by Hodson (1944), are chiefly of radiological interest, to the clinician they may serve as a rough guide to the degree of healing of the lung. When the track is healed it appears as a dense narrow band, connecting the sites of entry and exit, or the entry with the retained foreign body. Fig 298 shows a healing track connecting entry and exit



FIG 298—Healing track, partly solid and partly containing air

wounds. However, in severe pulmonary contusions it is rare to see these tracks, for the radiological picture is blurred by the extent of the pulmonary haematoma. The presence of a pulmonary contusion more than any other factor, renders patients with chest wounds unsuitable subjects for radical primary surgery. The embarrassment due to a haemothorax can be relieved by aspiration and the blood-loss made good by transfusion, but a wet lung due to a pulmonary haematoma remains a danger. During a long anaesthetic there is a risk of aspirating blood into the opposite lung, this danger is increased when the contused lung is handled. Moreover, the lung itself is not in a condition fit for surgery, unless an unnecessarily radical operation such as lobectomy of the contused lobe is undertaken. A contused lung will not hold sutures well and early operations on such damaged lobes nearly always fail to prevent subsequent infection. The majority of pulmonary haematomata resolve spontaneously, a few pass on to pneumonia, fewer still to an abscess.

Atelectasis is frequently associated with pulmonary contusion, especially if a haemothorax is also present. The majority of these collapsed lobes

expand spontaneously with the help of simple breathing exercises, in resistant cases, if there is sputum, postural drainage is of value. Only very rarely, four or five times in the whole series, has a bronchoscope been passed on such patients, and then not until simpler measures had been given a trial for two or three weeks. Atelectasis in a lower lobe due to aspiration of blood from a wound in an upper lobe usually clears up much sooner than a collapse in a wounded lobe, as would be expected, for it is simply a temporary block in the bronchus of an otherwise healthy lobe.

Blast injuries may complicate the issue in all chest wounds, but it is outside the scope of this paper to discuss the condition. In the majority of cases, by the time the patient reached the Centre, symptoms due to blast were minimal.

### Pleural Cavity—

*Pneumothorax* alone is relatively infrequent, though in nearly all haemothoraces there has been an initial pneumothorax. When a pneumothorax is present without effusion, it has been left to be absorbed spontaneously. The lung is thereby given a rest and rapid spontaneous re-expansion is the rule. If it were certain that the pneumothorax was only due to a sucking wound with no pulmonary contusion, it would be more logical to aspirate it as soon as possible, but in practice it is usually not possible to exclude a lung contusion.

*Tension pneumothorax* is relatively rare, 24 cases in the whole series (1.5 per cent). It is always serious, both immediately and remotely. Ten of these patients died later from sepsis associated with bronchopleural fistula.

*Haemothorax* is the major complication of penetrating wounds, embarrassing respiration in the early days and favouring infection in subsequent weeks. Its frequency is shown by the 1027 cases which occurred in this series (62.6 per cent). Of these, 718 remained uninfected and fluid, 217 were infected and fluid, and 92 were clotted or multilocular. Three-quarters of the last group were infected and they are considered later. In the whole group of 1027, there were 229 empyemata (22.3 per cent). Infection is therefore still the major factor in the management of a haemothorax. The advocates of aspiration have always stressed that the sooner the blood is removed from the pleural cavity and the lung allowed to expand, the less chance of infection, and the more localized such infection will be if it occurs. Air replacement is harmful because a large pleural space remains open to infection, moreover, it does not stop bleeding from the chest wall, which was the site of bleeding in half the cases of secondary haemorrhage, a complication which though uncommon is worth further consideration.

*Secondary Haemorrhage*—In those cases in which the bleeding came from the lung, in three it appeared that a retained foreign body was the cause, in the fourth there was such a large rent in the lung that it is very doubtful whether a pneumothorax would have prevented further bleeding. It is fortunately rare for further bleeding to occur into the pleural cavity after the first twenty-four hours. There were only 8 such cases.

*Case 1*—Penetrating mortar wound, entry just below the middle of the right clavicle, the fragment being

retained in the right upper lobe near the posterior end of the oblique fissure. No hæmothorax appeared till the tenth day, when he became febrile and developed a partly clotted hæmothorax.

Another case was of the same type, two others occurred three and eight days respectively after the last aspiration. The other four, however, were precipitated by aspiration, for in each case a sudden increase in the size of the hæmothorax was apparent two to three hours after the completion of this operation.

*Case 2*—Penetrating mortar wound, entry in the seventh space in the left posterior axillary line, the fragment being retained just in front of the seventh intercostal vessels. The hæmothorax was first aspirated six days after the injury, when 600 c.c. of thick blood containing scanty pus cells and *Staph. aureus* was aspirated, penicillin being replaced. On the tenth day 850 c.c. of pale sanguinous effusion, containing pus cells but sterile, was aspirated and penicillin replaced again. Towards the end of the operation he began to cough, but otherwise the aspiration was uneventful. He complained of no "tightness" in the chest and no air was replaced. A quarter of an hour later he collapsed and soon signs of a large hæmothorax were present. Two pints of fresh blood were immediately aspirated and even then it was obvious that more remained. After a blood transfusion a thoracotomy was performed, which showed the pleural cavity to be full of blood, both liquid and clotted, the bleeding came from the seventh intercostal artery, on which the foreign body was lying. He made an uneventful recovery and returned to duty two months later.

There is, therefore, an extremely slight risk of starting bleeding by aspiration, this can be minimized by slow evacuation of the blood from the pleural cavity, especially if the aspiration is performed under general anaesthesia, when the patient's sensations are not available as a guide in assessing the intrapleural pressures. Rapid aspiration under these conditions may leave a dangerously negative pressure which encourages further bleeding. When secondary hæmorrhage does occur it is probably safer to operate early rather than to wait for further bleeding before abandoning conservative treatment, as the following case illustrates.

*Case 3*—Penetrating shell-wound, entry 2 in to the left of the sternum in the fourth interspace. Six days after injury, 900 c.c. of blood and about 300 c.c. of air were withdrawn and the wound sutured under pentothal anaesthesia. One hour later he had gross surgical emphysema with a bulging left chest. An intercostal catheter was introduced to relieve the tension pneumothorax, air and blood escaping in considerable quantity. He was so much better the next day that the catheter was removed. Further aspirations were performed on the twelfth and sixteenth days, by which time it appeared that the chest was nearly dry. On the twentieth day a large hæmothorax appeared again and a thoracotomy was performed. There was severe bleeding from the hilar region of the left upper lobe, but unfortunately the adhesions were now so dense that they could not be separated quickly to enable the lobar pedicle to be grasped. The patient died before the bleeding could be controlled. A shell splinter had penetrated the pulmonary artery to the upper lobe.

Here a lobectomy would have been easier at the time of the first hæmorrhage before the adhesions were so dense.

## CLOTTED HÆMOTHORAX

The main features of this condition have already been described (Lush and others, 1944), so that here only one or two additional observations will be recorded. Clotting is twice as frequent on the right as on the left side, for there were 61 right and 32 left loculated or clotted hæmothoraces. Though a hæmothorax is commoner on the right owing to the greater early mortality of left-sided wounds, yet there is a relatively increased incidence of clotted right hæmothorax, for only 56 per cent of all fluid hæmothoraces were on the right and 44 per cent on the left. Thus apparent tendency of the right



FIG 299—*Case 4*. Bullet in the spine. Left hæmo-pneumothorax, with complete atelectasis.

hæmothorax to clot may be due in part to associated liver wounds, for clotting seems to be favoured in these cases. There is no doubt that some clots are absorbed slowly, but absorption of large clots usually leaves considerable pleural thickening with limitation of movement. This is not surprising because of the frequency of low-grade infection in these cases. The tragedy of conservative treatment when generally applied is that many cases will ultimately develop an empyema at a time when the chest is already frozen by thickened pleura. Though penicillin may sterilize many of the loculi in a clotted hæmothorax, it does not always reach the centre of the fibrin clots, which remain a source of infection. Evacuation of clots, therefore, decreases the risk of late infection. The obliteration of the dead space remaining when the clots have been removed is effected by stripping the membrane from the surface of the lung, which is then expanded immediately with positive pressure anaesthesia. Organisms are frequently grown from this sheet of organizing fibrin even when they are absent from the clot, as the following case illustrates.

**Case 4**—Entry wound over the left shoulder, with a bullet retained in the body of the seventh dorsal vertebra. Complete collapse of the left lung with an uninfected hæmothorax. Two weeks later a thoracotomy was performed for the removal of the bullet, the lung was decorticated in order to allow it to expand at once, though here the indication for the thoracotomy was the retained bullet. A pure growth of *Staph aureus* was obtained

operation of clot clearance without decortication there is still some risk of an empyema developing. This patient illustrates what can be achieved with radical surgery in these cases. In those who developed an empyema there was frequently an anterior pleural pocket that required separate drainage. In recent operations two anterior intercostal drains



FIG 300—Case 4. Left lateral radiograph showing bullet in the spine.



FIG 301—Same case. Result six weeks after decortication.

from the membrane peeled from the lung surface, though the rest of the hæmothorax was sterile. The radiographs (Figs 299, 300) show the pre-operative condition and Fig 301 the result six weeks later when he left the hospital for convalescence.

Decortication not only allows the lung to expand early, but also removes more infected fibrin. If an intrapulmonary missile has to be removed, or a bronchopleural fistula needs repair, suture of the lung is much easier after this membrane has been stripped away from the surface of the visceral pleura.

**Case 5**, with a penetrating mortar wound, a small fragment being retained in the left upper lobe. He had three aspirations with penicillin replacement before admission to the Chest Centre. By then the hæmothorax was clotted and infected with *Staph aureus*. Radiographs (Fig 302) showed a total clotted hæmo-pneumothorax. Thoracotomy three weeks after the injury, with evacuation of all blood-clot and removal of the foreign body, decortication of both lobes and immediate expansion of the lung. A course of parenteral penicillin was given for the first five days after operation, the drainage tubes being removed in three days when radiographs had shown the lung to be expanded and no appreciable fluid remaining. He made an excellent recovery, returning to Base duties six weeks after his operation. The blood, the clot and the membrane peeled from the lung in this case all grew *Staph aureus* on culture. Fig 303 shows the result six weeks after operation.

Such a case with conservative treatment nearly always forms an empyema, even with a limited

operation. In addition to a posterior drain in the ninth space. The anterior drains are usually placed in the fifth space in the anterior axillary line and in the second space in the mid-clavicular line when the upper lobe is completely collapsed. With this technique there is a better chance of the upper lobe expanding completely, without leaving a residual anterior pleural pocket to become infected.

### EMPHYEMA

The empyema rate in penetrating chest wounds should vary with the location of the Chest Centre, the farther back the Centre is placed, the larger the proportion of empyemata. In actual practice this selection of septic cases for the Chest Centre seems to have made no difference to the empyema rate in hæmothoraces, which remains the same now with the battle far away as it was when patients arrived within twelve hours of wounding. In the Middle East the empyema rate in hæmothoraces was 33 per cent, in the Central Mediterranean Forces it fell to 25 per cent in the first three months, and has since remained at 17 per cent. (The empyema rate in all penetrating wounds of the chest is now 12 per cent, the 17 per cent incidence refers to hæmothorax only.) In the first three months in the C.M.F. penicillin was injected into many of the infected hæmothoraces, but it was not used as a routine. In the last nine months it has been the rule to replace 30,000 units of sodium penicillin in 50 c.c. of saline

at the end of an aspiration, moreover, this practice has been started in the forward units. Some of the credit for the fall in the empyema rate must therefore be attributed to penicillin, for the rest, the forward and base surgeons must share the honours, the former for his excision of the parietal wound and aspiration of the hæmothorax, and the latter for the evacuation of clotted hæmothoraces, removal of intrapleural foreign bodies, and re-expansion of the lung. It

### CHRONIC EMPYEMA

There are five factors in war wounds of the chest which favour the development of a chronic empyema —

- 1 The wound of the lung may produce a permanent scar, with inability of the affected lung to expand
- 2 Prevalence of *Staph aureus* infection, an organism which produces no fibrinolysin

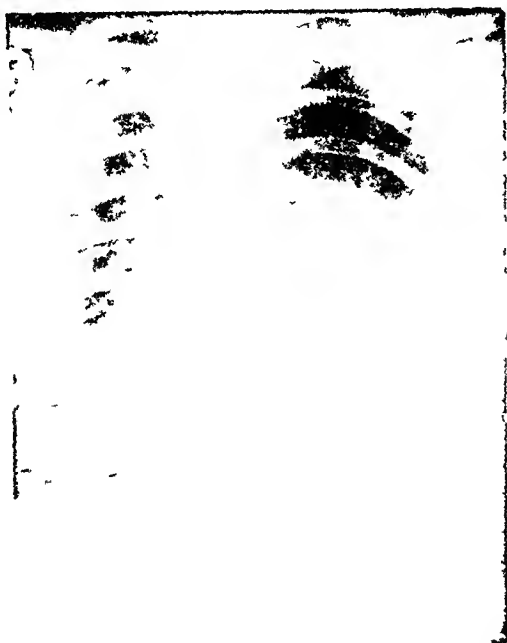


FIG 302—Case 5 Left infected hæmopneumothorax, atelectasis of left lung



FIG 303—Same case Result six weeks after decortication

is here that decortication may have prevented empyemata in some of the infected clots, by rapid obliteration of the pleural dead space. Another factor which is not always appreciated is that penicillin has done more than anything else to encourage early aspiration of the hæmothorax, since it cannot be introduced into the pleural cavity without an aspiration being performed.

Does the intrapleural use of penicillin result in fewer drainage operations for the infected hæmothorax? The test is whether pus, once present, will disappear and the lung expand completely. It is not enough to say that penicillin will sterilize many infected hæmothoraces, it undoubtedly will do so, but in this series there were 15 such infected liquid hæmothoraces which settled without suppuration in the days before penicillin. There was, however, only one case in which an empyema was treated by aspiration and settled completely before penicillin was available. There have been several small empyemata which have settled completely with aspiration and penicillin replacement. The presence of a bronchopleural fistula or fibrin clot, however, will usually doom conservative treatment to failure, and even if a 'cure' is obtained, where fibrin is present in much quantity, the functional result is poor, gross pleural thickening and limitation of movement, even scoliosis in some cases, seems to be the price paid for avoiding orthodox drainage.

- 3 Retained foreign body
- 4 Bronchopleural fistula
- 5 Fibrin deposit on the visceral pleura, which is very tough and unyielding

In trying to prevent chronic empyemata, clearly nothing can be done to remove the first factor. Penicillin helps to prevent the second. The third is a purely surgical problem, if the foreign body is intrapleural or in direct contact with the pleural space through a bronchopleural fistula it must be removed. If large and deep in the lung it may still be delaying expansion of a lobe. The controversy will be about the fourth and fifth. Many bronchopleural fistulae will close spontaneously, some take a very long time, during which the patient is continually in danger of aspirating septic material from the empyema into the bronchial tree. The longer the fistula remains, the tougher the ensheathing membrane on the surface of the lung becomes, a stage is then reached, sometimes not till after four or five months, when the fistula closes but the lung fails to expand. Thoracoplasty may ultimately be the fate of these cases. It is in the total empyema in which there is no sign of expansion of the lung two to three weeks after preliminary drainage that there is a place for decortication, repairing any fistula that may be present and expanding the lung immediately at operation. The advantage of this method is well illustrated by the following case



*Case 6*—Left thoraco-abdominal wound, with a left hæmothorax and a perforation of the stomach. By the time he reached the Chest Centre, one month after wounding, there was a total empyema containing much infected clot. This was drained by rib resection, the clots being mopped out. Two weeks later, as there was no sign of expansion, a decortication of both lobes was done. Although the membrane was very dense, once the layer was found decortication was easy and the lung expanded with pressure. The drainage tube was replaced, being made airtight, and an intercostal tube was placed in addition in the fourth space in the anterior

and *Fig 308* four weeks later. *Fig 309* gives the temperature chart.

One criticism of the method is that there is a possible danger of insufflating septic material into remote bronchioles when pressure is applied by the anaesthetist, though there may be a similar danger of sucking debris into the depths of the lung when air is removed from the pleural cavity with a pneumothorax apparatus, since the same difference in pressure must exist if the lung expands in each case. This is not a serious danger, for in most of these



*Fig 304*—*Case 6*. Total empyema, two weeks after drainage



*Fig 305*—Same case, two months after decortication

axillary line. A course of parenteral penicillin was given. These drains continued to drain small anterior and posterior pleural pockets, till eight weeks after the operation when the anterior sinus was completely healed, a small postero-basal sinus remained, a tube track only. The lung was otherwise fully expanded and the patient in excellent health. *Fig 304* shows the collapse persisting two weeks after instituting drainage, and *Fig 305* the result two months after decortication.

In this case drainage was necessary, but expansion of the lung was hastened. In the next case to be recorded, prolonged drainage was avoided by early operation.

*Case 7*—Wounded Dec 12, 1944, entry in the sixth space in the anterior axillary line on the left, the fragment perforating the upper lobe and lying in the neck. He was aspirated five times before arriving at the Chest Centre three weeks later. He then had a loculated pyothorax, with thin pus in an anterior loculus, from which only coliforms and diphtheroids were grown. He had a swinging temperature to 102° nightly. Thoracotomy one week later and evacuation of clots and pus, the upper lobe was adherent at the wound of entry, but otherwise both lobes were completely collapsed. Easy decortication and complete expansion. Temporary intercostal drainage to second and sixth spaces anteriorly, and in the ninth space in the posterior axillary line. The anterior drains were removed on the fifth day and the posterior on the ninth, when the foreign body was removed from the neck. The fever settled promptly and he made an uninterrupted recovery, being fit for convalescence six weeks later. *Fig 306* shows the pre-operative condition, *Fig 307* two days after operation,

cases the lungs are not 'wet' and are in no way comparable to the septic lungs of civilian practice. Routine post-operative bronchoscopy showed so little secretion that it was considered unnecessary. In a few cases sputum has been excessive, and operation on this account has been contra-indicated.

Another criticism is that a wounded lung requires time to heal, and it may be better to leave it collapsed until healing is complete. The experimental work of Montgomery (1943) suggests, on the contrary, that the process of repair in lung wounds will be quicker and more complete in a fully expanded lobe. Unfortunately in so many of these cases it is the lower lobe which bears the burden, even when the wound has been of the upper lobe alone. Often the upper lobe is expanded, but the hæmothorax has prevented the lower lobe from expanding, so that the healthy lobe remains collapsed till the clot is removed. But even with a wounded lobe, by the time the decortication is done, not usually till three to four weeks after wounding, the wound track will not be disrupted by the pressure necessary to expand the remaining lung. On many occasions a waist-like constriction corresponding to the healed track appears in the wounded lobe when it is re-expanded.

A bronchopleural fistula will not be made if the entry and exit wounds in the lung are duly respected, stripping should be very gentle here, and if firmly adherent it is much better to leave this portion unstripped rather than run the risk of opening up a fistula which has recently become sealed. The

fear of disseminating infection and causing a septicæmia has been exaggerated, it may be that the patients have been protected by chemotherapy, for

They are usually small and situated commonly at the apex, at the anterior costophrenic angle, and at the base. Even if one or all of these pockets require



FIG 306—Case 7. Total loculated pyothorax. The large foreign body is in the neck.



FIG 307—Same case, two days after decortication, the drains in situ.

it is the routine to give a five-day course of parenteral penicillin in these cases. There is no evidence that infection has ever been spread by decortication.

drainage, it is still true that the patient may be more fortunate than he would be waiting for spontaneous expansion to occur in a total empyema.



FIG 308—Same case four weeks after decortication.

Fig 310 is a photomicrograph of the membrane peeled from the lung. As organization of the membrane advances it becomes increasingly difficult to separate it from the visceral pleura, the optimum time for the operation being within the first two months.

Finally, although decortication may expand the lung, it may leave pleural pockets where pus accumulates if an empyema forms. This is true, unless complete expansion occurs such pockets may remain

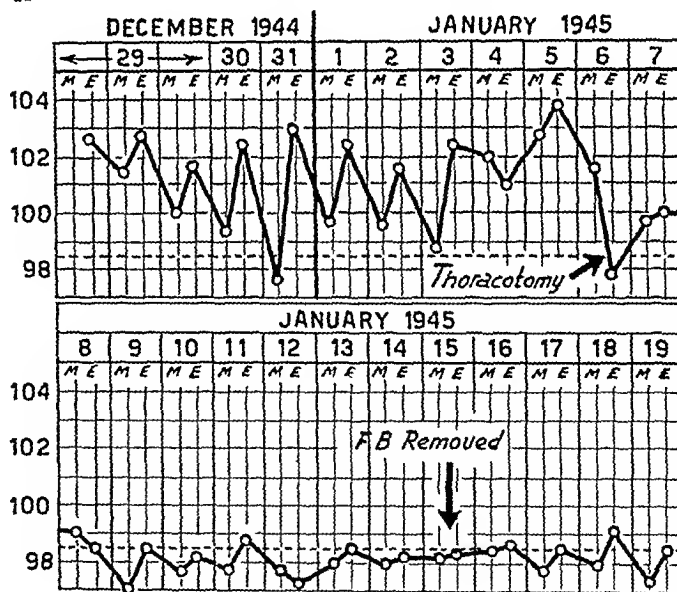


FIG 309—Same case. Temperature chart.

## THORACO-ABDOMINAL WOUNDS

Here a definition is necessary. Only wounds which have some obvious sign of pleural penetration will reach the Chest Centre, the others will go to the general surgeons. Classified as thoraco-abdominal are all penetrating wounds of the chest in which the missile has penetrated the abdominal cavity, whether it causes symptoms or not. Hence many cases were only diagnosed as thoraco-abdominal

after fluoroscopy, when the foreign body was seen in the abdominal cavity. Altogether there were 164, of which 101 were on the right and 63 on the left. Intervention by the forward surgeon was more often required in left-sided wounds, including splenectomies, sutures of stomach, and repair of diaphragm. On the right side conservatism in liver injuries is more common than operation, in those cases in which operation has been performed, it usually

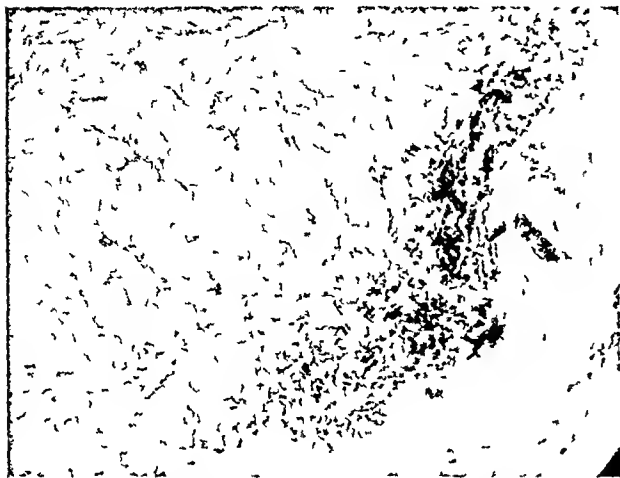


FIG. 310.—Photomicrograph of the membrane removed by decortication. *Histological report by Major G. J. Cunningham, R.A.M.C.* The progressive organization of the membrane is well seen. There are three areas—

1. A pale rather homogeneous layer on the right, the surface facing the pleural cavity, which consists of fibrin.
2. A larger area on the left and occupying most of the picture, consisting of well developed fibrous tissue.
3. An intermediate zone, darker in colour, which shows vascular congestion and the presence of large numbers of histiocytes, containing yellow pigment. This pigment was assumed to be bilirubin, as it gave a negative iron reaction. The section was taken from a patient with a thoraco abdominal wound with a bile stained loculated hæmothorax, the fibrin forming the outer part of the membrane was consequently stained yellow by absorption of bilirubin. The picture gives an idea of the extent of the fibrous organization and emphasizes the importance of early operation, if decortication is to be successful.

consisted of a laparotomy for severe intraperitoneal hæmorrhage. The transthoracic approach to the liver has not been much favoured by British forward surgeons, unless a sucking wound of considerable size has pointed the way. Subphrenic abscesses have been encountered in the proportion of 13 on the right to 7 on the left. It is unusual for these abscesses to show a fluid level, or for much help to be afforded by radiographs, a raised diaphragm so often accompanies wounds in the lower chest that it may have no other significance. Bile must often escape into the pleural cavity in right-sided wounds, but fortunately an established choelothorax is rare, for in most cases the fistula soon closes. In 6 cases bile continued to accumulate in the pleural cavity and they all become infected with coliform organisms, forming empyemata. There were two cases of bronchobiliary fistula, in which large quantities of bile were expectorated. One patient, with a perforating thoraco-abdominal wound, started to cough up bile for the first time after twelve days and continued to do so for two weeks, when the fistula closed. In the other, 12 oz. of bile were coughed up daily, here there was a large foreign body deep

in the substance of the liver. He died of toxæmia from continued sepsis before the foreign body could be removed, the fistula having persisted for six weeks without showing any signs of spontaneous closure. Many small tears of the left diaphragm have been repaired by forward surgeons, five left-sided herniæ were repaired at the base, one right liver hernia was not submitted to operation, since it was not increasing and the patient was well. The mortality in this group is high, even at the base, there were 11 deaths in the left-sided and 12 in the right-sided wounds, a mortality of 22 per cent.

## RETAINED METALLIC FOREIGN BODIES

**Intrapleural**—A foreign body free in the pleural cavity commonly causes an empyema, there were 26 empyemata in 39 patients with such foreign bodies. There is a clear indication, therefore, for early removal of such fragments. If the associated hæmothorax is uninfected, penicillin replacements after aspiration may prevent infection during the time occupied in evacuation to the base and in localization of the foreign body. But the delay in removal should not be too great, though hasty operation in an unfit patient is even more harmful. These are the foreign bodies which will most frequently be removed by the forward surgeon at the primary operation.

**Pulmonary**—Several years must elapse before a correct assessment of the danger associated with a retained foreign body in the lung can be made. That there is a real danger of infection and late hæmoptysis is evident from the experience of many surgeons who have seen such patients in the years between the two wars, but the frequency of such complications can only be properly assessed by a combined study of the later histories of those men who still retain their foreign bodies. The policy has been to remove large pulmonary foreign bodies (1 cm. x 2 cm.) wherever situated, to remove small (1 cm.) fragments if in close proximity to mediastinal or hilar structures, and to leave small peripheral or 'safe' foreign bodies unless causing symptoms. 'Safe' here is a relative term, it implies only that there are reasonable grounds for assuming that the first hæmoptysis will be small and not immediately fatal, as might be the case with a foreign body near the hilum. At first it was felt that there was considerable risk of infecting the pleural space, to prevent this the peripheral missiles were removed in two stages after forming pleuropulmonary adhesions. This is not satisfactory. It is always more difficult to find the metal, and a more extensive resection of rib is required than in the one-stage operation. Furthermore, the fear of pleural sepsis was greatly exaggerated. Although organisms have been found on culture in 17 out of 31 foreign bodies removed across a clean pleural cavity, if the operation is done at the correct time there is little fear of an empyema developing. Only one of the above cases developed a localized empyema, and here the operation was done too early, for the pulmonary hæmatoma had not completely resolved and it was difficult to suture the lung. Though adhesions resulting from a hæmothorax may often help to limit infection, the most important single factor in avoiding infection is to delay the operation till the

pulmonary hæmatoma around the foreign body has completely resolved. In the majority of cases, therefore, an interval of three or four weeks should elapse after the injury before the removal of the missile. Some missiles may need removal at an earlier date on account of sepsis or hæmoptysis, but in general the lung requires a rest before it is fit for surgery. It may be impossible to suture lung which has been recently contused, when the

Depot. Ten weeks after wounding he came up to the hospital for a routine review and returned to convalescence for another month. One week later he reported because he had developed tachycardia and dyspnoea with retrosternal pain. On examination he had low fever, the pulse was regular at 140, with distant heart-sounds, a scarcely perceptible apex beat, and there was a slight increase in the cardiac dullness. There was no friction. Radiographs confirmed the increase in the heart shadow, showing a pericardial effusion. In four



FIG 311—Case 8 Foreign body in the pericardium, two months after injury (The other fragment is in the right upper lobe)



FIG 312—Same case, ten weeks after injury, during the first attack of pericarditis

hæmatoma has subsided the foreign body may be safely extracted and the lung sutured. In the other 30 cases in which intrapulmonary fragments were removed, infection of the pleural space was already present at the time of operation. Two patients who had moderate-sized foreign bodies had late hæmoptysis, one year and three months respectively after wounding, the fragments were removed in each case at this stage. In 8 cases a lung abscess has been due to a retained foreign body, but only in 1 was this a putrid abscess, in 3 instances a local pneumonotomy for drainage and removal of the fragment was possible, without opening the general pleural cavity, 1 was associated with a total empyema, the other 4 were little more than benign foreign-body abscesses and caused no further trouble after the fragment was removed.

**Pericardial**—Fragments lodged in the mediastinum have been removed when large and near the œsophagus or great vessels. Smaller pieces may be left, usually without disability, with the exception of fragments in, or adjacent to, the pericardium. Even tiny fragments in this situation may cause effusions in the pericardial sac, of which the following is a typical example—

**Case 8**—Had multiple mortar wounds with a right hæmothorax. There were two small retained fragments in the chest, one in the right upper lobe and the other in the anterior part of the pericardium. There was no cardiac abnormality at first, so that after the hæmothorax had been evacuated he went to the Convalescent

days the pain and tachycardia disappeared and he seemed well again. Two weeks later he had a similar attack, lasting four or five days. Electrocardiographs now showed normal QRS complexes and simple inversion of the T-waves in all leads, described by Paul Wood (1937) as the T<sub>2</sub> pattern. In consultation with Brigadier Boland and Lt-Col Paul Wood, it was agreed that the foreign body was causing pericardial irritation and that it should be removed. The sixth rib on the left side was divided just lateral to its junction with the cartilage and the sixth costal cartilage divided half an inch from the sternum, the rib and cartilage being turned down as a flap hinged on the sixth intercostal muscles. The pleura was so adherent to the pericardium that it could not be reflected, so a transpleural route was adopted. The foreign body lay in a little pocket of dirty granulation tissue in the fibrous pericardium, the pericardial sac was not opened. *Coliform* bacilli were grown from the fragment on culture. He made an uninterrupted convalescence and has had no further attacks of tachycardia. Fig 311 is a radiograph two months after the injury, before he had shown any pericardial symptoms. Fig 312 is a radiograph taken two weeks later during the first attack of acute pericarditis.

This patient illustrates the syndrome of recurrent pericarditis from irritation by a foreign body. Pericardial effusions have been caused by other foreign bodies, which, though not in the pericardial sac, were in contact with it during some phase of the heart cycle. Four of these were in the lingula segment of the left upper lobe, in each case there was evidence that the fragment had impinged on to the adjacent pericardium, which

showed a local inflammatory reaction. Two other fragments, which were considered to be in the pericardium, were embedded in the myocardium, but so near its surface that they were in contact with the pericardial sac. It is the fragment in direct contact with the pericardial sac which may cause recurrent attacks of pericarditis, as these pieces can be removed with very little risk, it is well that operation should be considered as soon as there are signs of recurrent irritation of the pericardium. The initial reaction of the pericardium to the wound is not an indication for operation, but another attack of pericarditis shows that the fragment is causing trouble and it should be removed during a quiescent phase, when the attack has settled. It is possible that pericarditis would not recur after the second or third attacks, but since the foreign body is a proven menace, and as the operation in itself is not dangerous, it is wiser to remove the fragment once it is certain that it has caused trouble. Pericardial or juxta-pericardial foreign bodies are removed with much less risk than are those which are deeply embedded in the myocardium, fortunately the latter do not seem to cause symptoms so often and their removal is not usually necessary.

**Vertebral Foreign Bodies**—A serious complication is a fragment retained in a vertebral body, especially when it is associated with an empyema. Osteomyelitis of the spine is almost inevitable in such cases, though by no means certain when there is not an empyema. Occasionally the fragment can be removed easily by the transpleural route during a thoracotomy for pleural toilet or drainage, but it more often needs a second planned operation after the empyema has been drained. Then an extrapleural approach, with resection of two ribs and mobilization of the bundle, is satisfactory. In the after-care, involving a plaster bed and continued drainage of the pleural cavity, a balance must be struck between recumbency and the optimum position for draining the empyema, this can usually be effected by raising the head of the bed.

### REHABILITATION

Breathing exercises, with control of the good side, are started early. They may do harm in infected cases and so should be postponed in non-suppurative infected hæmothoraces in which the temperature and infection appear to be settling with conservative treatment, several times fever has returned with too early rehabilitation in these cases. But with this exception, the sooner exercises begin the better. Special attention should be paid to the diaphragm, as this is frequently adherent, individual tuition in diaphragmatic respiration can here be of much value. There is a tendency, not confined to the laity, to regard a man who has had a hæmothorax as permanently unfit for full combatant service. This is partly due to the conception that all diseases of the lung are serious and a full recovery is unusual,

partly to the idea that a chest wound is a 'Blighty' wound. With proper rehabilitation, which must include shoulder movements and general physical training, the majority of patients with uninfected hæmothoraces are soon fit for duty, first usually base duties, but many return to full combatant duties within three months.

### MORTALITY

The mortality in the whole series of 1639 chest wounds at the Centre was 4.27 per cent.

### SUMMARY

- 1 A series of 1639 penetrating chest wounds is analysed.
- 2 Secondary hæmorrhage in a hæmothorax is rare.
- 3 A clotted hæmothorax is often infected, evacuation of the clot and decortication is recommended.
- 4 The prevention of chronic empyema is discussed, decortication is of value in selected cases.
- 5 The indications for removing metallic fragments are outlined.
- 6 Fragments near the pericardium may cause recurrent attacks of pericarditis.

**Acknowledgments**—This was the work of a Team. Lt-Cols J G Scadding and E H Rink, Majors O H J M Telling and J C Nicholson, Capts R W Lush and C R Stevenson were all at some time my colleagues, and to them my thanks are chiefly due. In addition, it is a pleasure to thank the Consulting Surgeons, especially Major-General Ogilvie and Brigadier Edwards, for their help, Brigadier Boland and Colonel Churchill for their interest, Lt-Col Paul Wood, who has analysed the cardiac wounds with me, Major Cunningham for pathological studies, Major Maddocks for the radiographs, Capt Brownell and Mr Hennell for the reproductions, and Pte Coupland for much clerical assistance.

Finally, acknowledgments are due to the various Officers Commanding Hospitals in which the team has worked, particularly Col W J F Craig, OBE, Officer Commanding the Hospital in which the majority of the work has been done.

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## SURVEY OF ABDOMINAL WOUNDS IN 21 ARMY GROUP (JUNE, 1944—MAY, 1945)

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THE abdominal wounds treated in 21 Army Group form the largest single group of cases operated upon in this war by British or Dominion surgeons, and the recovery-rate in the series has been relatively more favourable than usual. It is felt therefore that a statistical survey may help either to confirm or confound many impressions formed by those dealing with the cases.

The following table (*Table I*) gives the total figures from D-day to VE-day (June 6, 1944—May 8, 1945). These figures represent the work of over 100 British and Canadian forward surgeons, and of one attached Belgian Field Surgical Unit.

*Table I*—ABDOMINAL AND ABDOMINO-THORACIC CASES  
SUMMARY OF RESULTS D-DAY TO VE-DAY

TYPE OF CASE	CASES	DEATHS	PERCENTAGE MORTALITY
Penetrating or perforating abdominal wounds with intraperitoneal visceral injuries	3579	1065	30
Abdominal wounds with extra-peritoneal visceral or vascular injuries, or intraperitoneal hæmorrhage with no discoverable visceral injury	740	73	10
Thoraco-abdominal or abdomino-thoracic wounds	786	333	42
Totals	5105	1471	29

Complete accuracy under the conditions prevailing during a war of rapid movement is obviously difficult to secure, yet every effort has been made to obtain the correct mortality-rates by cross-checking all death reports against the initial reports of the surgeons concerned, and it is believed that the figures are as nearly accurate as possible. The proximity of the United Kingdom, combined with the constant strain on hospital accommodation in B.L.A., meant that most abdominal cases were evacuated as soon as was reasonably safe—on an average about the eleventh or twelfth day—and it is therefore evident that the table does not provide the true final results. From the available incomplete information it would appear that the percentage of men with abdominal wounds who died after evacuation to U.K. was low.

An interesting pointer in this connexion is given in a recent report of 317 abdominal wounds by the Consulting Surgeon, NZEF (Col T D M Stout, CBE). In this series, treated and retained for considerable periods in C.M.F. during the Italian campaign, only 16 deaths occurred at Base Hospital level, and in the last eight months of the period under review none at all.

It should also be appreciated that the figures in the above table refer only to those abdominal cases that came within the scope of the forward surgeon,

i.e., they exclude deaths occurring before a surgical level of evacuation was reached. Here again the N.Z. report merits comparison, where a very similar post-operative mortality of 27 per cent is correlated with an *overall* mortality-rate of 50 per cent.

### SCOPE OF INVESTIGATION

In dealing with such large numbers as in *Table I* many analyses may be made provided sufficiently detailed records are available, but in the course of the campaign certain aspects became of more practical importance, and I have in the main concentrated upon these. Owing to information on essential points being incomplete, either relatively or in fact, many records were found to be unsuitable for detailed analysis for reasons given below.

Reports with adequate details for study of the points enumerated below involved analysing the records of—

1038 men who had laparotomies for abdominal wounds (343 deaths)

912 men who died following laparotomy (including above 343)

208 men who were operated upon for thoraco-abdominal or abdomino-thoracic wounds

The analysis, therefore, covers 1815 cases, and it is believed that these represent a fair sample of the entire total of 5105 cases.

#### PART I ANALYSIS OF LAPAROTOMIES FOR ABDOMINAL WOUNDS (1038 CASES)

- A Nature of the missiles producing the wounds
- B Sites of entry
- C Frequency of involvement of individual viscera
- D Operative procedures used and their relative results
- E Frequency, distribution, and effect of associated wounds
- F Incidence of complications
- G Mortality-rate—
  - 1 Overall mortality
  - 2 Mortality related to groups of viscera involved
  - 3 Mortality related to individual viscera involved
- H Analysis of results related to status of patients

#### PART II ANALYSIS OF FATAL CASES FOLLOWING LAPAROTOMY (912 CASES)

- A Time of death after operation
- B Causes of death
- C Correlation of the two preceding analyses
- D Analysis of deaths due to peritonitis—
  - 1 Wound/operation interval
  - 2 Incidence and degree of peritoneal soiling

### PART III THORACO-ABDOMINAL AND ABDOMINO-THORACIC WOUNDS (208 CASES)

- A Frequency of involvement of individual viscera
- B Surgical approach employed
- C Mortality-rate —
  - 1 Overall mortality
  - 2 Mortality related to visceral involvement

#### SOURCES OF INFORMATION

The information has been extracted from the monthly reports submitted by surgeons of field surgical units, casualty clearing stations, and forward (200 beds) hospitals, and from the reports on deaths rendered by all units. It was a rule that *all* deaths had to be reported, but the official *pro forma* merely requested that all interesting cases, including abdominal and thoraco-abdominal cases should be recorded. As a result the information about the fatal cases was relatively more complete, and if a survey were made by extracting all cases with *sufficiently complete details* from all available reports a false picture would be obtained since a disproportionate number of deaths would be included.

Considering the stress under which surgeons often worked, the quality of most reports was very good, but naturally individuals had their own ideas about the relative importance of various factors and findings, with consequent variation in records. Nearly all surgeons supplied complete details about their more serious and spectacular cases, the ones naturally carrying the greatest risk, and either they or their parent unit supplied reports on all fatal cases. On the other hand, many reported their successes very briefly, e.g., "Gnr Smith, J, R A, S W Pent Abdo Three holes in ileum sutured. Uneventful recovery, Evacuated." For this type of investigation such records, lacking in certain essential details such as site of entry, wound/operation interval, operation/evacuation interval, etc., are insufficient.

The problem arose, therefore, of securing a representative sample of the whole series, and has been answered by using only those reports containing adequate records of *all* cases. Reports in which the less serious cases were recorded briefly and only the more serious or fatal cases in detail were rejected. This has been considered essential if a balanced picture is to be obtained, although such strict selection has meant the elimination of some large groups with much more favourable recovery-rates than the average, e.g., one series of about 200 cases with a mortality-rate of approximately 20 per cent\*.

A leavening of the more experienced field surgeons was always introduced at strategic forward points, and these men operated upon a relatively greater number of cases. Their skill and experience produced excellent results and saved many desperate cases, yet these men were often so busy that they had least time to prepare the detailed reports required to provide the best material for a statistical analysis.

\* I understand that an analysis of this very fine series is to be published elsewhere by the surgeon concerned—Major B. Eaton, R C A M C.

The non-utilization, for the reasons stated, of a number of such reports explains the somewhat higher mortality-rate in the sample than in the gross total. The figures in the analysis represent an over-estimate rather than an under-estimate of the mortality—admittedly a fault, but one in the right direction.

### PART I ANALYSIS OF 1038 LAPAROTOMIES FOR ABDOMINAL WOUNDS

#### A Analysis of Nature of Missiles (Table II)

—There were 361 cases in which the nature of the missile was unknown or was not stated. Many men cannot say what weapon produced their wounds, and even when the foreign body is discovered it is not always possible to determine its origin.

Table II

MISSILE	TOTAL	PERCENTAGE
Shell	288	43.0
S. A. A.	278	41.5
Mortar	30	4.0
Mine	24	3.5
Bomb	22	3.0
Vehicle	15	2.0
Grenade	13	2.0
Crush	4	.6
Bayonet	2	.3
Blast	1	.1
Totals	677	100.0

Owing to some looseness in terminology the above figures are possibly rather inaccurate. There was a tendency to record wounds as due to G. S. W. when the missile was not small-arms ammunition, this gives a higher figure to that group than was probably the case. Mortar injuries were almost certainly more common than 4 per cent, but were often recorded as shell wounds.

**B Analysis of Sites of Entry Wounds (Table III)**—There were 238 cases in which the exact site of entry wound was not stated. Cases under the heading 'Chest' are those in which the entry wound was above the costal margin but did not involve the diaphragm, cases under the heading 'Nil' were injuries due to blast, falling masonry, vehicle accidents, etc.

Table III

SITE	TOTAL	PERCENTAGE
Anterior abdominal wall	330	41.250
Buttock	151	18.875
Right flank	87	10.875
Left flank	83	10.375
Posterior abdominal wall	53	6.625
Thigh	36	4.500
Chest	30	3.750
Nil	30	3.750
Totals	800	100.000

The relatively high proportion of entry wounds in the thigh is noteworthy, as is also the fact that the buttock was second only to the anterior abdominal wall as the commonest site of entry.

**C Frequency of Involvement of Individual Viscera (Table IV)**—In 1038 laparotomies lesions



were found of 1544 individual viscera. Multiple lesions of individual viscera have been counted as one lesion. In 24 cases no intraperitoneal lesion was discovered, although in some of these there was intraperitoneal hæmorrhage. The relative frequency is expressed as a percentage of the total lesions (*Fig 313* also sets out the findings in pictorial form.)

Table IV

ORGAN	LESIONS	PERCENTAGE OF TOTAL LESIONS
Small intestine	484	31.34
Colon	380	24.61
Liver	157	10.16
Rectum	109	7.05
Miscellaneous	108	7.05
Stomach	107	6.93
Bladder	95	6.15
Kidney	58	3.75
Spleen	26	1.67
Pancreas	20	1.29
Totals	1544	100.00

The group under the heading 'Miscellaneous' includes lesions such as the mesentery, the omentum, and the retroperitoneal tissues—and one pregnant uterus.

It is interesting to note that the intestinal tract (from stomach to rectum) accounts for 70 per cent of the lesions. The stomach and the rectum appear to be equally vulnerable and the small intestine shows a significantly higher percentage of lesions than the colon.

**D Analysis of Operative Procedures Used and their Relative Results (Table V)**—An attempt has been made to assess the results of different operative procedures. To get a true picture it has been necessary to discard all cases that had multiple abdominal lesions or which died from associated wounds.

Table V

ORGAN	OPERATION	TOTAL	DIED	PERCENTAGE MORTALITY
Liver	Suture	14	3	21.4
	Packing	8	5	62.5
	Drain only, or nothing	36	5	13.9
Spleen	Splenectomy	8	1	12.5
Kidney	Nephrectomy	17	6	35.3
Bladder	Suture	4	1	25.0
	Suture and suprapubic	23	4	17.4
Stomach	Suture	19	4	21.0
Small intestine	Suture	139	22	15.8
	Resection	54	20	37.0
Colon	Suture	13	3	23.1
	Exteriorization	95	27	28.4
Rectum	Colostomy	30	9	30.0

The majority of liver injuries required neither suture nor packing. When either of these was necessary the mortality rose, the increase being much greater in the case of packing. The high mortality in kidney wounds of battle origin should be noted and is again evident in *Table XI*.

As expected, the majority of small-intestinal lesions were treated by suture. When resection was necessary the mortality was over twice as great. The apparent relative success of suture of the colon can

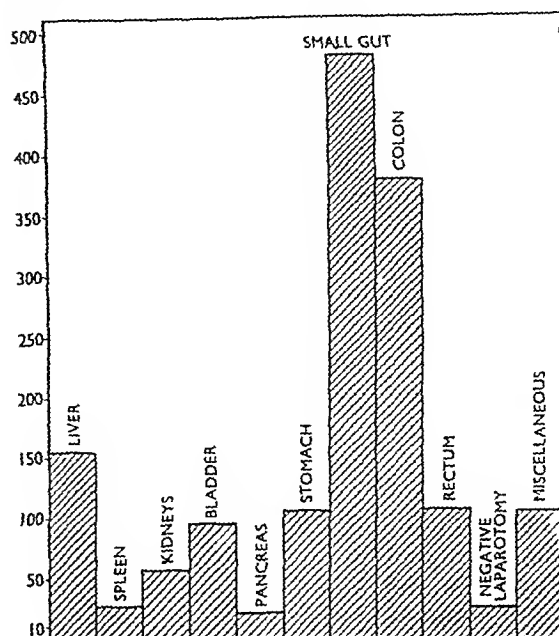


FIG 313—The frequency of involvement of individual viscera (1038 cases, 1544 lesions)

be to some extent accounted for by the fact that only in minor wounds of the large intestine was it likely that this procedure would be carried out. The well-recorded, but often forgotten, mortality associated with a colostomy is borne out by the above figures.

### E Frequency, Distribution, and Effect of Associated Wounds (Table VI)

In the 1038 patients there were 207 men with other wounds of sufficient gravity to be recorded (20 per cent). For the purpose of analysis these are recorded under three headings—

**Class I—Minor Wounds** These include soft-tissue wounds, the less serious open fractures, and superficial wounds of the head and chest. There were 62 such cases. (Trivial wounds are not recorded.)

**Class II—Severe Wounds** These include penetrating wounds of the head and chest, more serious open fractures, amputations, and spinal injuries. There were 123 such cases.

**Class III—Severe Wounds Directly Responsible for Death** The only cases placed in this category are those in which the evidence suggested that the

associated wounds played an overwhelming part in the death of the patient. There were 22 such cases.

**Effect of Associated Wounds on Mortality-rate**—As stated above, in 22 cases (2.13 per cent of the total) the cause of death was due to the severity of the associated wounds rather than to the abdominal

Table VI—DISTRIBUTION OF ASSOCIATED WOUNDS

SITE OF WOUND(S)	NUMBER OF CASES	PERCENTAGE
Open fractures and traumatic amputations	88	42.51
Flesh wounds of limbs	60	28.99
Spine	22	10.62
Chest	18	8.70
Head	15	7.25
Trunk	3	1.45
Multiple wounds	1	.48
Totals	207	100.00

wound. An estimation of the effect on the mortality-rate when an abdominal wound is complicated by another wound can be gained by determining the mortality-rate for abdominal wounds alone and

Table VII

CLASS	TOTAL	RECOVERED	DIED	PERCENTAGE MORTALITY
Abdominal wounds alone	831	583	248	29.84
Abdominal wounds with other wounds	207	112	95	45.89

abdominal wounds associated with other wounds (Table VII)

In this series there was a 16 per cent increase in the mortality-rate when an abdominal wound was associated with another serious wound.

**F The Incidence of Complications (Table VIII)**—I believe the number of complications recorded is lower than actually occurred. Many surgeons did not mention them unless they gravely affected the course of the patient's post-operative history. This is well shown by the number of cases of jaundice reported. Transient jaundice was a very common complication, every one of the small number of cases recorded below was of sufficient gravity to prejudice the chances of recovery.

Table VIII

COMPLICATION	NUMBER
Abdominal wall —	
Burst incision	11
Severe infection	15
Pentoneal infection —	
Pelvic abscess	3
Subphrenic abscess	1
Intestinal obstruction —	
Dynamic	16
Organic	6
Respiratory —	
Bronchopneumonia	19
Massive collapse	3
Pulmonary embolus	7
Miscellaneous —	
Uræmia or anuria	14
Jaundice	13
Mental changes	12
Fæcal fistula	7
Pancreatitis	1
Mesenteric thrombosis	1

Even in this necessarily incomplete series, the relative frequency of anuria and jaundice is worthy of note.

### G Mortality-rate —

**I Overall Mortality (Table IX)**—When estimating the overall mortality-rate in this series every

Table IX

TOTAL NUMBER OF LAPAROTOMIES	DEATHS	PERCENTAGE MORTALITY
1038	343	33.04

patient who died in forward areas after a laparotomy or an attempted laparotomy has been included. The figure includes men who died from other wounds and those who died during the induction of anaesthesia prior to operation.

**2 Mortality Related to Groups of Viscera Involved (Table X)**—The cases have been divided into four main groups according to the viscera damaged: wounds of the alimentary tract, wounds of the solid viscera (including the bladder), combinations of these two groups, and wounds of the supporting structures and tissues (including mesentery, omentum, peritoneum only, and retroperitoneal tissues).

Table X shows that injuries of the solid viscera

Table X

GROUP	TOTAL	RECOVERED	DIED	PERCENTAGE MORTALITY
Alimentary tract	594	398	196	32.99
Solid viscera	135	100	35	25.92
Combinations of above	177	87	90	50.84
Supporting structures	108	90	18	16.67
Negative laparotomies	24	20	4	16.67

are less lethal than wounds of the alimentary tract, and that when the two are combined the mortality-rate rises steeply. The death-rate in men with lesions of the supporting structures and in those where no visceral injury was discovered is perhaps surprisingly high. This is partly due to the presence of other serious wounds in several of the cases concerned. The figures confirm the impression that a laparotomy on any wounded man involves a serious risk to life.

**3 Mortality Related to Individual Viscera Involved (Table XI)**—This table provides a comparison between the mortality-rate when only one viscus is involved and when it is injured in combination with others. (Also shown in Fig 314.)

Several groups in this table are so small that the possible range of statistical error is great. It reveals once again the much greater risk associated with multiple lesions. The mortality-rate in men with genito-urinary injuries is higher than most imagine, while the figures do not confirm the common belief that wounds of the colon are far more dangerous

Table XI

ORGAN	NUMBER OF CASES		PERCENTAGE MORTALITY	
	Alone	Combined	Alone	Combined
Small intestine	203	281	24	48
Colon	177	263	11	69
Liver	58	99	24	48
Rectum	39	70	36	50
Bladder	28	67	21	45
Stomach	20	87	25	51
Kidney	17	41	35	56
Spleen	9	17	11	69
Pancreas	1	19	—	42

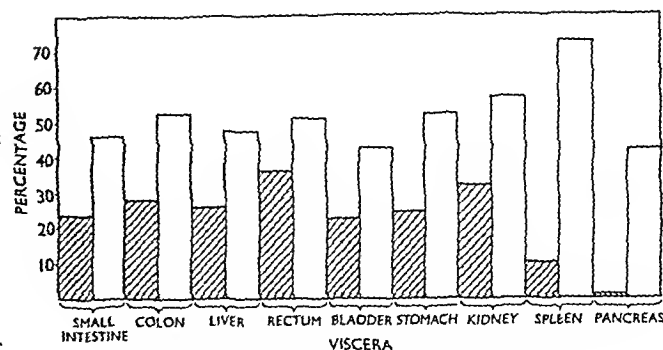


FIG 314—Mortality in wounds of individual viscera (alone and combined)

than wounds of the stomach and small intestine. Rectal wounds, however, both alone and in combination maintain their sinister reputation.

**H Analysis of Results Related to Status of Patients (Table XII)**—The cases have been divided into officers, other ranks, prisoners of war, civilians, and unknowns.

Table XII

GROUP	TOTAL	PERCENTAGE OF ALL CASES	PERCENTAGE MORTALITY-RATE
Officers	55	5	36
Other ranks	742	72	33
Prisoners	167	16	35
Civilians	37	3.5	49
Unknowns	37	3.5	11

It will be seen that *qua* fatal abdominal wounds, officer and man appear to be exposed to almost equal risk. The mortality amongst prisoners is unexpectedly low. Owing to difficulties of collection and evacuation from the battlefield and the tendency to operate on Allied personnel first, there was naturally a greater delay before a prisoner reached operation. It was expected that there would be a corresponding increase in the mortality-rate, but this expectation is not confirmed. The probable explanation may be the 'natural selection' that occurs when there is a delay in operation—only the less serious cases surviving long enough to reach the surgeon. The high mortality-rate among civilians may be due to two factors: their poor general condition due to inanition, and the undue proportion of old people and infants in this group.

The low mortality among the group of 'unknowns' is due to the fact that only four death reports in this series did not give the rank of the patient.

## PART II ANALYSIS OF 912 FATAL CASES FOLLOWING LAPAROTOMY

In order to get a larger sample of deaths, a further 569 cases with detailed records were selected and added to the 343 already available from the first analysis of 1038 laparotomies. This provided a total of 912 cases.

**A Analysis of Time of Death after Operation (Table XIII)**—This table confirms the findings in previous reports which have stressed the point that the majority of deaths occur in the first two or three days after operation.

Table XIII

INTERVAL	NUMBER	PERCENTAGE OF TOTAL
Death in theatre	55	6.0
1st day	385	42.2
2nd day	148	16.2
3rd day	83	9.1
4th day	41	4.5
5th day	51	5.6
6th day	25	2.7
7th day	32	3.5
8th day	11	1.2
9th day	10	1.1
10th day	13	1.3
11th day	7	0.8
12th day	6	0.7
13th day	7	0.8
14th day	6	0.7
15th day	5	0.6
16th day	2	0.3
20th day	2	0.3
28th day	1	0.2
Not stated	22	2.3

seven days. In this respect a comparison with the figures of the N.Z. series is of interest. Corresponding figures are 70 per cent in 48 hours and 50 per cent in 24 hours.

**B The Causes of Death (Table XIV)**—The term 'Shock' has been used to describe the cause of death in those severe cases that never picked up after operation. This group, two cases in every five, consists of those cases the gravity and extent of whose injuries made them really hopeless from the start. They simply serve as an indication of the forward surgeon's willingness to tackle even the most forlorn chance.

Those under the heading 'Respiratory Obstruction' died as the result of inhaling vomit during or after operation. The figure of 1.2 per cent is disquieting, but patients often reach the surgeon with their stomachs full of glutinous stew and the anoxæmia that results while this clinging mass is sucked from the air-passages may be sufficient to tip the scales in a gravely shocked patient with a precariously balanced cardiovascular system. That death should have occurred so often from this cause suggests that time would be well spent in employing some prophylactic measures against vomiting, and emphasizes

the value of adequate pre- and post-operative treatment in preventing such calamities

Many of the cases of peritonitis or retroperitoneal and pelvic cellulitis were established before operation was possible. As subsequently shown the average wound/operation interval in all cases was 12 hours, but in the cases dying from peritonitis it averaged 21 hours

Table XIV

CAUSE	NUMBER	PERCENTAGE OF TOTAL
Shock	358	39.4
Peritonitis	102	11.1
Associated injuries	43	4.7
Renal failure	30	3.3
Intestinal obstruction		
<i>a</i> Dynamic	13	
<i>b</i> Organic	6	
<i>c</i> Unstated	11	
Pneumonia	28	3.1
Hæmorrhage	22	2.4
'Heart failure'	22	2.4
Sepsis (extraperitoneal)	18	2.0
Pulmonary embolus	15	1.6
Respiratory obstruction	11	1.2
Liver damage	5	.5
Mental changes	5	.5
Unknown	223	24.5

was carried out to show the interval after operation at which the various causes were predominant

The table sets out the findings in detail and the graph (Fig 315) shows the salient points more clearly

The following points merit comment—

1 'Shock' The first 24 hours is the peak period for death from shock

2 *Peritonitis* Contrary to expectations the deaths from peritonitis reach their peak on the first to third days. They remain fairly steady, but at a much lower level, on the fourth to eighth days and thereafter only occur sporadically. This interesting result is partly explained by the fact that some of these cases undoubtedly reached the surgeon very late, with peritonitis already established before operation. A comparison of the wound/operation interval in all fatal cases and in those dying from peritonitis is given in the next section and the wound/death and operation/death intervals should not be confused

This is not the whole story, however, and it seems probable that the almost universal use of penicillin in 21 Army Group as a routine part of the treatment of abdominal cases may have controlled or prevented many of the later septic complications

Table XV

CAUSE OF DEATH	NUMBER OF DEATHS ON DAY AFTER OPERATION																											
	0*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Unknown
Shock	35	246	4	14	1	2																						6
Peritonitis	1	25	17	23	6	8	4	4	3		2	1				2	1								1	1		3
Associated wound(s)	3	15	11	3	3	2	1	1				1		1														1
Renal failure			3	4	8	8	1	3		1	1																	1
Intestinal obstruction		1		1	3	9	5	4		1	1		1		1	2												1
Pneumonia			4	4	3	3	4	3	2	1	1	1	1			1												
Hæmorrhage	8	10									1			1														2
'Heart failure'	1	6	5	4	2	3								1														
Sepsis	2	2	2		1			3			1	1	2	1	2													1
Pulmonary embolus			1	3	3	2		1	2		2																	1
Respiratory obstruction	1	6	2	1																								1
Liver damage			1		1				1				1															1
Mental changes		1		2		1				1																		
Unknown cause	4	73	48	24	12	12	9	13	3	5	4	2	2	3	3		1								1			4

\* 0 refers to the day on which operation was performed and the other figures on this horizontal line represent days after operation

The number of lung infections was low, and it should be noted that in almost 5 per cent of deaths severe associated wounds were responsible rather than the abdominal wound itself

Again, the relative importance of renal failure (anuria)—see Table VIII—as a cause of death is well shown by its place in the list

C Correlation of the Time of Death and the Cause of Death (Table XV)—This analysis

These always account for a proportion of the deaths after the first few dangerous days when the mortality is greatest

3 *Intestinal obstruction* Deaths from this cause occurred most often between the fourth and seventh days. These were of the dynamic type. Sporadic deaths occurred up to the fifteenth day, and this latter group were due to organic obstruction

4 *Renal failure* 90 per cent of the deaths from renal failure occurred between the second and seventh days. The peak was on the fourth and fifth days.

5 *Cause unknown* Everyone who has seen many abdominal cases due to wounds is only too familiar with those disappointing cases that die for no discoverable reason. In the words of the old song, "they simply fade away"—and in the majority a post-mortem examination provides no clue to the cause. Doubtless if full laboratory facilities were generally available in forward areas some visceral or biochemical upsets would be detectable, sufficiently adequate alone or in combination to sever the thin-spun thread of life.

6 *Associated wounds* When these were sufficiently severe to be regarded as mainly responsible for the fatal issue, the death occurred most frequently during the first two days.

#### D Deaths due to Peritonitis —

1 *Wound/Operation Interval* — The average interval from the time of wounding to operation in all cases in this series was 12 hours.

The average interval from the time of wounding to operation in

all cases that died from peritonitis was 21 hours. As explained previously, in many of these the peritonitis was certainly established prior to operation.

It should be emphasized that the above figure means that nearly a day has to be added to the time of death after operation to get the true figure for death from peritonitis after wounding. This partially explains the somewhat unexpected finding (see Table XV and Fig 314) that peritonitis was responsible for approximately 7 per cent of the deaths during the early days of convalescence.

Table XVI

ORGAN	NUMBER OF LESIONS	PERCENTAGE
Liver	106	33
Spleen	64	20
Stomach	51	16
Kidney	40	12
Colon	31	10
Small intestine	17	5
Diaphragm alone	13	4
Totals	322	100

The wound/operation interval also includes the time spent on resuscitation. It has not been possible to assess how long this was on the average, but it is estimated at approximately two hours. This means that the average case reaches a forward surgical unit in 10 hours, and under the conditions frequently prevailing during a battle this is fine testimony to the efficiency of all concerned in the collection and evacuation of casualties from the field.

2 *Soiling* — Of 912 men who died, 121 were recorded as having significant soiling—13 per cent.

Of 102 men who died from peritonitis, 44 were recorded as having significant peritoneal soiling—44 per cent. Such figures require no comment.

### PART III INVESTIGATION OF 208 CASES OF THORACO-ABDOMINAL AND ABDOMINO- THORACIC WOUNDS

The records of 208 cases of thoraco-abdominal and abdomino-thoracic wounds have been investigated and the following information extracted —

A *Frequency of Involvement of Individual Viscera* (Table XVI) — In the 208 cases 321 viscera were found to be involved.

In this table naturally every grade of visceral injury is represented—from the trivial to the catastrophic. In all true thoraco-abdominal and abdomino-thoracic wounds the diaphragm is perforated and that was so in this series, but in a small number no associated visceral lesion was discovered. There may have been minor liver or lung damage, but the wise surgeon does not explore officiously.

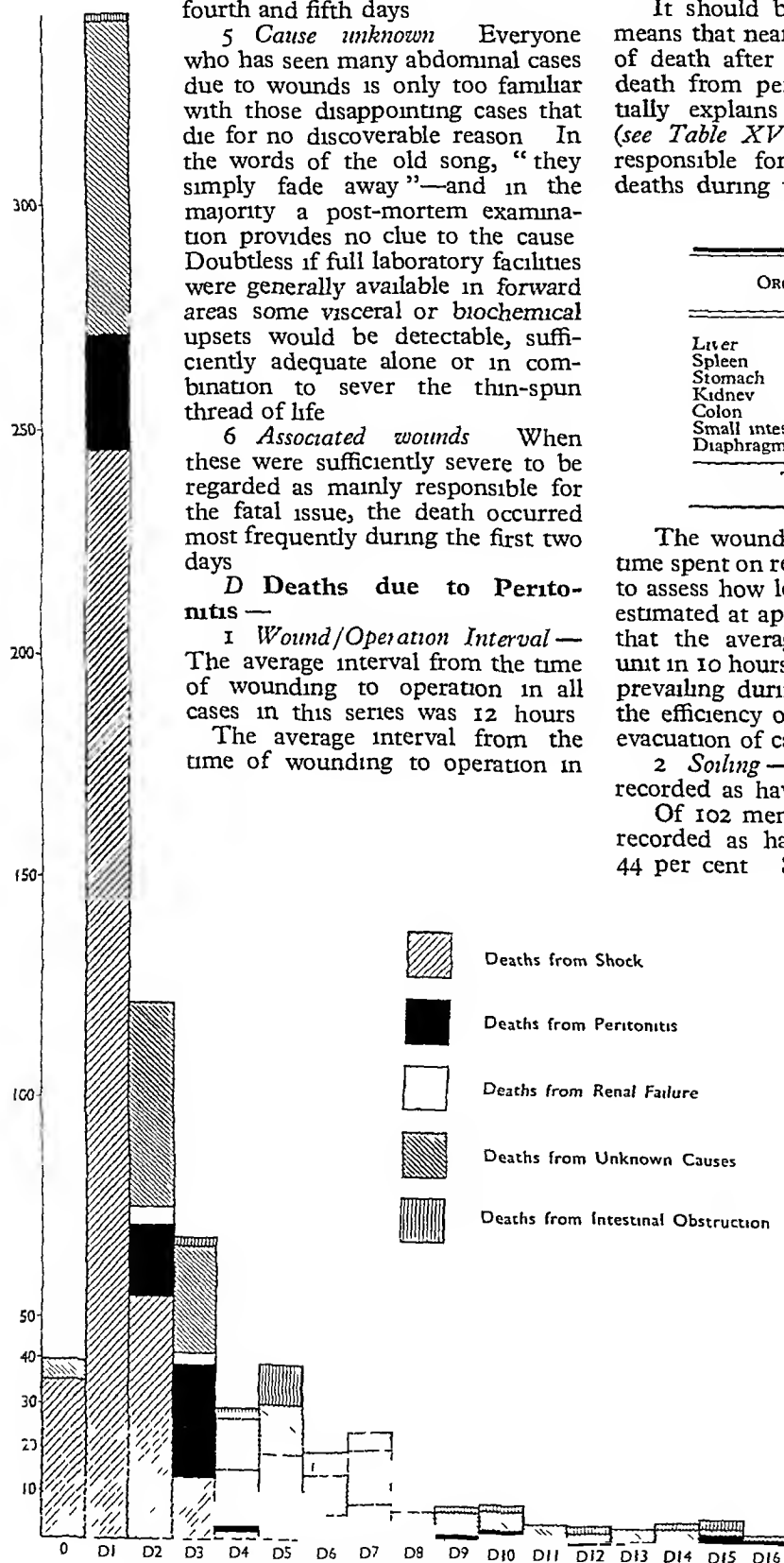


FIG 315—Major causes of death in relation to time of death

when there is obviously no major lesion requiring surgical attention

### B The Surgical Approach Employed—

Varying opinions have been expressed as to the relative merits of an abdominal or a thoracic approach in thoraco-abdominal wounds. An investigation was made to discover which was used more frequently. Thoracic incisions varied from orthodox intercostal incisions to wound extensions. The abdominal incisions employed were usually paramedian, rectus splitting, or occasionally oblique. It was not possible to differentiate in more detail the incisions used.

The necessary information was available in 124 cases—

	Cases	Per Cent
Abdominal approach	75	61
Thoracic approach	49	39

The mortality-rate was determined for each group, but the figure is not of great value as there were so many variables. Many of the thoracic approaches were simply explorations of wounds of the liver through the original wound.

	Per Cent
Mortality-rate for wounds explored through abdominal incisions	40
Mortality-rate for wounds explored through thoracic incisions	26

Many surgeons comment in their reports upon the fact that if the abdominal lesions are confined to the left upper quadrant a thoracic approach provides an excellent exposure, and that procedures such as splenectomy can be performed with ease by this route.

### C The Mortality-rate (Table XVII)—

1 Of the 208 patients in this series 80 died, a mortality-rate of 38 per cent.

2 Mortality related to visceral involvement

Table XVII

ORGAN	WOUNDED ALONE		WOUNDED IN COMBINATION		PERCENTAGE MORTALITY	
	Number	Died	Number	Died	Alone	Combined
Liver	55	8	51	29	15	57
Spleen	25	8	39	18	32	46
Stomach	7	3	44	30	43	68
Kidney	5	1	35	18	20	51
Colon	5	1	26	16	20	63
Small intestine	5	2	12	10	40	84
Diaphragm alone	13	5	—	—	26	—

The outstanding point brought out by this table is the high mortality associated with all wounds of the alimentary tract, whether injured alone or in combination. The fact that cases recorded under 'Diaphragm Alone' produced a mortality of 26 per cent and 'Liver Alone' one of 15 per cent, suggests that the injuries in the former group were more extensive than was detected at operation. It should be added that if a post-mortem was performed

and a 'missed' lesion found, most surgeons were sufficiently honest to record this in their reports.

### SUMMARY

Of the 5105 abdominal wounds reported during the 1944-45 North-Western European campaign a series of 1815 has been selected as a suitable sample of the whole for statistical analysis.

This analysis has been divided into three parts—

- 1 1038 laparotomies for abdominal wounds
- 2 912 fatal cases following laparotomy
- 3 208 thoraco-abdominal wounds

The findings have as far as possible been recorded in tabular form. The following findings of interest are amongst those that emerge from the analysis—

- 1 An overall mortality of 29 per cent is reported in 5105 cases of abdominal and thoraco-abdominal wounds.
- 2 The intestinal tract (stomach to rectum) accounts for 70 per cent of the wounds.
- 3 The small intestine is injured more frequently than the colon, the mortality in both groups is very similar.
- 4 Injuries of the solid viscera are less lethal than those of the intestinal tract.
- 5 The association of another serious wound with the abdominal wound raises the mortality-rate 16 per cent.
- 6 Officer and man seem equally liable to death from abdominal wounds.
- 7 The buttock is second only to the anterior abdominal wall as the commonest site of entry.
- 8 Jaundice and anuria were amongst the commonest post-operative complications.
- 9 1.25 per cent of deaths were due to preventable respiratory obstruction.
- 10 64.4 per cent of all deaths occurred in the first 48 hours after wounding, 48 per cent in the first 24 hours.

11 Average wound/operation interval was 12 hours, in deaths from peritonitis 21 hours, these latter being most frequent from the first to the third day post-operatively.

12 The highest mortality in the thoraco-abdominal cases occurs in the group in which the abdominal part of the injury involves the alimentary tract.

My grateful thanks are due to the DMS, 21 Army Group (Major-General E Phillips, CB,

CBE, DSO) for permission to publish this paper, to Lt-Col B McN Truscott, who, with the staff of his Field Surgical Unit, was entirely responsible for the production of all the figures used in this report, to Lt-Col G A G Mitchell for invaluable help in deciding the scope of the investigation and the form of its presentation, and to all the Forward Surgeons of 21 Army Group whose excellent reports have made that presentation possible.

## SPONTANEOUS GANGRENE OF THE SCROTUM (FOURNIER'S GANGRENE)

By O T MANSFIELD

THE occurrence of complete and apparently causeless gangrene of the scrotum in an otherwise healthy patient is an unusual condition and of sufficient interest to warrant a report of the following case

### CASE REPORT

A man of 43 was admitted to an E M S hospital moribund. No accurate history was available at the time, but his wife has since been able to penetrate the fog of toxic amnesia with a few details of the onset and course of the disease. Five days before admission the patient first noticed "pain and swelling in the lower parts", until that time he had been well except for a heavy cold, which was still upon him. The swelling continued, and on the next day delirium first appeared, from this time amnesia was complete. On the third day his wife noticed that the inflamed parts had turned very white. Toxaemia was considerable at this time and increased with the progressive change of the inflamed area to a white colour

gangrenous. This gangrene extended along the under-surface of the penis for the full length and for a width of about  $1\frac{1}{2}$  in of the circumference of the oedematous part. Incision into the area produced a free flow of turbid fluid, culture of which gave a heavy growth of haemolytic streptococci +++ and *Staph aureus* ++.

The scrotum was then split into halves by division in the plane of the septum, and before the urethra was reached bleeding vessels were found. Dissection was continued laterally on either side until the whole of the gangrenous area was removed, together with the affected under-surface of the penis. This gave a most remarkable appearance. All that remained of the scrotum was three triangular flaps about  $1\frac{1}{2}$  in in length and of equal width at the base. Two of these were based laterally and one posteriorly. Between them lay both testes completely exposed, the parietal layer of the tunica vaginalis having been removed. These and all the structures of the spermatic cords were entirely normal, the former being covered with an unaffected serous layer. Anteriorly the cords disappeared beneath the



FIG 316—Condition on admission to plastic unit about ten days after operation. Marginal sloughs having separated. Area of skin loss which is just visible at the base of the penis extends along the whole of the under surface.



FIG 317—Condition one year after discharge from hospital. Both testes are freely mobile in the scrotum. There is a scar band between the under surface of the penis and the anterior surface of the scrotum, but this produces negligible disability.

**ON EXAMINATION**—The patient was extremely ill, cerebration was sluggish and answers to questions could only be obtained after repetition. There was gross dehydration with a dusky, yellow coloration of the skin. Examination locally showed, between his thighs, a cold flaccid mass about the size of a coco-nut. This was an entirely gangrenous scrotum, from which a horrible smell arose, the penis was extremely oedematous, and there was spreading cellulitis from the pubic region to the costal margin on both sides and extending outwards into the loin. This was most marked in the iliac fossa and faded out as the costal margin was reached. Enlarged inguinal glands were present, but without evidence of cellulitis. The patient was too ill to warrant any active interference, but after the administration of intravenous glucose-saline his general condition was sufficiently improved to justify surgical intervention.

**AT OPERATION**—Examination in the lithotomy position showed that the whole of the scrotum, with the exception of three small triangular areas, was entirely

overhanging edge of pubic skin. Section of the area removed showed no abnormality other than marked interstitial oedema with many thrombosed vessels. Investigation of the urinary tract was not carried out at operation as it was felt that this might precipitate a renal infection. Before operation the patient had passed a few ounces of clinically normal urine without difficulty.

**PROGRESS**—Five days after operation the general condition was sufficiently improved for him to be transferred to an E M S plastic unit for convenience of dressings in the saline bath and for consideration of plastic repair of the area excised. By this time the cellulitis of the abdominal wall had completely subsided, and apart from a small margin of slough around the skin edges the wound was clean (Fig 316). About a week later he was out of bed. Separation of the remaining sloughs and epithelialization occurred rapidly. Six weeks after operation the patient was discharged soundly healed.



He attended for review some two months later, when there were no urinary symptoms, a 14/16 bougie was passed without difficulty and there was a well-formed but small scrotum in which the testes were freely mobile. Further surgery to free the posterior part of the penis from the anterior scrotal wall was refused by the patient. Fig 317 shows the condition one year after discharge.

## DISCUSSION

Spontaneous gangrene was originally reported by Fournier in 1884, when three salient features of the condition were described. These were (1) The explosive onset in an otherwise healthy man, (2) The rapid progress of the gangrene, and (3) The total absence of the usual causes of gangrene. Since then cases have been reported from time to time in the literature which have more or less fulfilled these criteria, but a study of these reports shows other factors which are common in a majority of cases. These are —

1 Extensive and fairly constant area of gangrene. While cases of partial loss have been reported, in many of the published series gangrene was of the pattern described above and involved a similar area. Although no description of the three flaps observed by us has been encountered, the photograph of a case reported by Brown and Smith (1939) shows a very close correspondence with Fig 316. The integrity of the testes and the inguinal and anal regions appears to be constant. It has been noted specifically in previous reports that although sloughing of the anterior abdominal wall has been recorded, reports of involvement of areas other than the penis and scrotum are extremely rare.

2 Rapid resolution of the adjoining cellulitis, together with a corresponding improvement in the patient's general condition when the sloughing area has separated.

3 A tendency for spontaneous repair to occur. This is very striking and has been noted with particular emphasis by earlier authors. We believe that this tendency strongly supports our contention that the three flaps described are present in all cases. The diagram (Fig 318) illustrates how difficult spontaneous closure would be if the loss extended to the sulcus between the perineum and the medial surface of the thigh, quite apart from the disability which would arise if a mass of scar tissue united the thighs in the coronal plane and the penis to the anus in the sagittal plane.

In two cases reported recently surgical repair has been attempted, in one by direct suture and undermining four days after the slough had separated, in which case obviously no time had been given for spontaneous closure. In the other, bilateral thigh flaps were used, again, soon after the separation of the sloughs.

**Aetiology**—Two theories are held as to the origin of this condition. The one favoured by most French authors is that it is a fulminating erysipelas. This does not explain why such a disastrous form of the disease should occur in this region, neither does it take into account those cases in which the infection is not due to hæmolytic streptococci. It is also noteworthy that this condition is not seen commonly in fever hospitals nor in association with burns. In fact, it was emphasized

in the original description that it arises spontaneously in otherwise healthy persons.

Gibson (1930) considers that the disease is in fact a gas gangrene due either to *B. Welchii* or to other anaerobes, in which sufficient search has not been made for the causative organisms. In support of this he claims, first, that "the rapidity with which the gangrene develops and the profound toxæmia which accompanies it have no parallel in gangrenous processes of known cause, with one exception, and that is gas gangrene", and secondly, that "streptococci usually occur in symbiosis with the gas-producing anaerobes, and, in fact, may obscure the true nature of the condition by their overwhelming numbers".

We are unable to accept the first statement, it must be generally accepted that the form of gangrene most rapid in its onset and development is one in

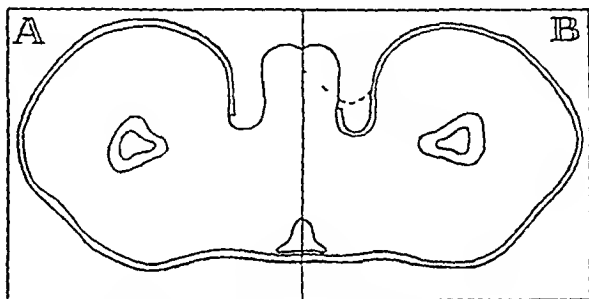


FIG 318—A, Diagrammatic cross section at the level of the perineum. An attempt to demonstrate that spontaneous healing, if the loss extends to the thigh, is impossible. B, Presumed method of healing, increased skin length in the transverse plane being obtained by stretching of the small scrotal flap together with lowering of the vertical depth of the sulcus between the thigh and the scrotum.

which vascular occlusion has suddenly developed. The second claim we admit as an isolated statement, but cannot consider it as a point of great value in determining the aetiology of the condition under discussion. Neither of these explanations explains how the infection arises, nor why adjoining areas, such as the anal, inguinal, or testicular regions, should survive unscathed amid such destruction. Nor do they account for the existence of the three flaps described in this case and which we believe to be usually present.

An alternative explanation is that the condition is a vascular disaster of infective origin, analogous to cavernous sinus thrombosis. The infection is not believed to have any specificity other than the existence of a pathogenic organism which causes rapid thrombosis in the vessels of the septum of the scrotum with consequent necrosis of the area supplied by these vessels. The extreme rarity of the condition strengthens the analogy to cavernous sinus thrombosis, for this latter, despite the existence of millions of infected lesions of the face in the world at any one time, remains a relatively uncommon condition.

The fairly constant pattern of the area sloughed is again adequately explained on a vascular basis, and only this pathology can account for the existence of the flaps described. These are supplied by the external pudendal branch of the femoral artery and the superficial perineal arteries. The localized skin

loss on the under surface of the penis is also to be expected as the dorsal vein remains intact, having no connexion with the veins of the mediastinum below the urogenital diaphragm

The onset of the gangrene in published cases has been from 12 hours to 15 days, with a maximum occurring at 3 days in 10 out of 40 cases reported by Gibson. This rapid gangrene is comparable to that occurring in a flap of skin and subcutaneous tissue which has become infected and its limited vascular supply destroyed by thrombosis. Gangrene in these cases occurs with extreme rapidity and the loss may be complete in a few hours. Under these circumstances the testes can be expected to escape.

#### Surgical Treatment—

1 Allen, reporting cases in 1894, recommended complete castration. This is, of course, quite unnecessary.

2 Since then the usual treatment appears to have been multiple incisions until the slough has separated, with the adjuvant use of anti-gas-gangrene serum, zinc peroxide, etc., according to the views held as to the aetiology.

3 On the basis of the theory postulated in this paper, radical removal of all sloughing areas is advocated not only to save time but to rid the patient of an area which is irretrievably lost. Excision also provides the freest possible drainage. Sulphonamides or penicillin would be useful adjuvants after the bacteriology had been determined. Repair would usually seem to be unnecessary.

**Mortality**—This in published cases varied between 22 per cent in 36 cases (Whiting, 1905) and in 145 cases (Coenen and Przedborski, 1911), to 31 per cent in 16 examples of this condition out of 147 cases of gangrene of the scrotum in the Philadelphia Hospital reported by Randall (1920). Death in most instances has been due to toxæmia. In a few, metastatic phenomena have developed.

**Bacteriology**—Gibson has collected 206 cases from the published reports, and these he divides into two categories: (1) Those with some coincident or antecedent lesion, and (2) Those in which no lesion can be discovered.

In the first category are cases which cannot be considered as Fournier's gangrene. These include cases of inguinal adenitis, wounds, and obstruction. Of the second group, in 98 no cause was given as being responsible for the condition and 23 had minor conditions present, of which 11 had given rise to pruritus locally. Of those in group (2), 15 were due to hæmolytic streptococci, 3 to staphylococci, 6 to mixed streptococci and staphylococci, and 1 each to *B. coli*, *B. fusiformis*, and *B. Welchii*, 5 were infected by bacteria called by a nomenclature which is not standard.

It will thus be seen that the overwhelming number of cases in which the bacteriology has been determined are due either to streptococci or staphylococci or to the two together.

**Literature**—This has been well summarized by Randal (1920), Gibson (1930), and Browne and Smith (1939). The first two of these authors give a very full bibliography. Since then cases have been reported by Carver (1939), Howard (1940), Lamiere (1940), and Hunter (1930). Some of these papers are not at the moment obtainable.

My thanks are due to Rainsford Mowlem, Surgeon-in-Charge, Plastic Unit, Hill End E.M.S. Hospital, for his help, to Dr A. C. Cunliffe, of Sector 4, E.M.S. Pathological Laboratory, for bacteriological assistance, and to Miss D. E. Orpen for the diagram.

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## A CASE OF HINDQUARTER AMPUTATION FOR CHONDROMYXOSARCOMA OF THE RIGHT THIGH

By IAN M. HILL AND IAN P. TODD

THE first operation of this type is reported to have been performed by Billroth in 1889, but it was not until six years later that the first successful case (performed in two stages) was recorded by Girard (1895). Since then, about 110 cases have been described with an operation mortality in the region of 60 per cent (Gordon-Taylor and Wiles, 1935; King and Steelquist, 1943). The nomenclature concerning the operation is very varied, but the type performed in the case reported below is perhaps best described as a transilio-interpubic hindquarter amputation. This is the first operation of its kind

to be reported at St. Bartholomew's Hospital, and the patient is, at present, well and free from complications.

#### CASE REPORT

**HISTORY**—E. B., aged 49, a painter, entered Friern Emergency Hospital on June 21, 1944, complaining of pain down the right leg and a lump below the right groin, of six weeks' duration. The pain had increased in severity and was exaggerated by movement or by pressure over the mass. The pain radiated down the front of the thigh to just below the knee. There was no history of injury. Varicosities had appeared on the

medial side of the calf recently. He had lost 8 lb in weight since the onset of symptoms.

**EXAMINATION**—The right leg was held in 30° of flexion. Extension beyond this and flexion beyond 90° were painful. All rotatory movements produced pain. Muscle spasm at the hip was considerable.

In the upper thigh anteriorly and immediately below the inguinal ligament, there was palpable a smooth, hard, globular, sessile mass 2½ in by 2½ in feeling like bone, attached deeply, but not to the skin. The femoral artery could be felt running superficial to the mass, but displaced somewhat laterally. There was no impulse on coughing. The chest was clear and the blood-pressure 134/88 mm Hg.

**X-ray Report (June 23) (Dr G T Loughborough)**—"The lesser trochanter of the right femur shows a destruction of bone, combined with a certain amount of proliferation of fresh bone into the soft tissues of the

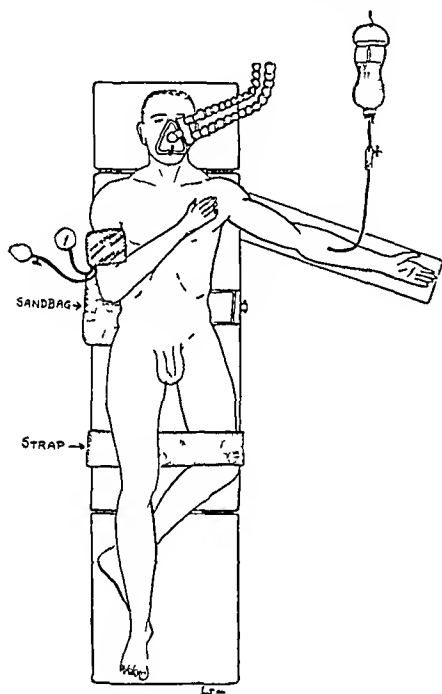


FIG 319—Position of patient on operating table

thigh. This proliferation gives an irregular feathery appearance. The destructive process does not extend deeply into the shaft of the femur. There is slight bone reaction, limiting its spread inwards. Two areas of decalcification can be seen, one in the lower part of the neck of the femur and one in the ischium just below the acetabulum. These suggest secondary deposits. The chest is normal.

**Conclusion** There is an osteogenic sarcoma of the right lesser trochanter, with secondary deposits in the right femur and right ischium."

A biopsy was performed by Mr J B Hume on June 26 through a 5-in incision parallel to the medial border of sartorius and 2 in below the anterior superior iliac spine. The lateral femoral circumflex vessels were divided and, presenting between the sartorius and rectus femoris, the tumour was found to arise from the femoral shaft close to the lesser trochanter. Macroscopically the tumour appeared to be a chondromyxosarcoma. This was confirmed by histological examination.

On July 7 the hæmoglobin was 94 per cent Haldane and blood group O (IV).

**OPERATION**—On July 10 a hindquarter amputation was performed by Mr J B Hume, of St Bartholomew's Hospital. The anæsthetic (pentothal, cyclopropane, oxygen) was given by Dr David Reckless.

The left medial antebrachial vein was exposed and a cannula for drip transfusion tied in place. The patient was placed on the operation table in the position indicated in Fig 319.

The first portion of the incision was made over the inguinal ligament (Fig 320), which was severed from its

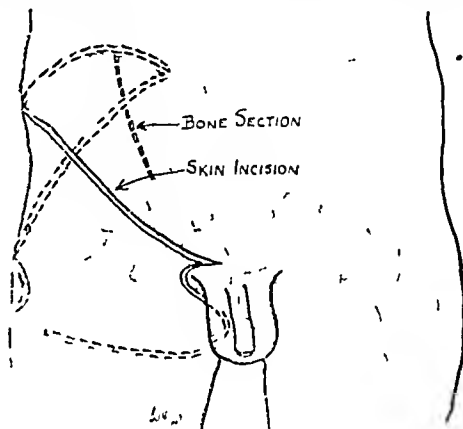


FIG 320—First portion of incision over the inguinal ligament

bony attachments. The peritoneum of the right iliac fossa was stripped up and the external iliac vessels exposed and ligated (the vein after elevation of the limb) and the femoral nerve divided. The lateral extremity of the incision was extended along the iliac crest to the posterior superior iliac spine, and deepened until the oblique and transversus muscles were divided. The peritoneum



FIG 321—The completion of the incision

was stripped up further, and a tape passed round the right common iliac artery. The rectus abdominis was detached from the pubic tubercle and symphysis and the retropubic space of Retzius opened. The limb was then widely abducted and flexed. The medial extremity of the first incision was extended along the conjoined ischiopubic ramus and the exposed bulb of the corpus cavernosum rugined from the bone. The bladder was then well retracted and the symphysis pubis divided with a knife. The limb was adducted and the incision carried from the ischial tuberosity to the greater trochanter and thence to the posterior extremity of the supracristal portion of the incision (Fig 321). The

section of gluteus maximus lying posterior to this last incision was raised in the flap so formed. The piriformis, which was not visible, was divided extrapelvically and a pair of Moyuahan's cholecystectomy forceps passed from within the pelvis to emerge through the greater sciatic foramen and used to draw a Gigli saw into position for dividing the ilium. An appropriate area of the ilium was cleared of the iliacus and the bone sawn through from the greater sciatic notch.

The sacrotuberous and sacrospinous ligaments were next divided and the innominate bone allowed to rotate laterally, giving a wide exposure of the pelvis. The psoas and femoral nerve were divided at the pelvic brim, the sciatic and obturator nerves were divided, the limb allowed to fall further laterally, to be freed by division of branches of the gluteal and internal pudendal vessels and of the levator ani.

The wound was closed by suturing the gluteal fascia to the anterior abdominal muscles over a corrugated drain and the skin closed in three flaps (Fig 322).

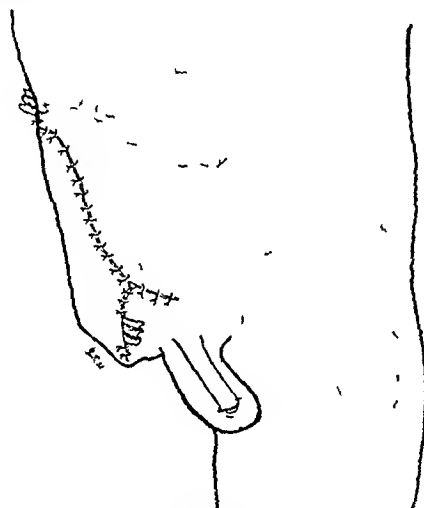


FIG 322—The amputation completed

The time occupied by the operation was 1 hour 25 minutes. 1600 c.c. of stored citrated blood were given during the operation, but, despite this, the blood-pressure fell to 90/85. One hour later, after a tidal drainage system had been erected and a further infusion of 560 c.c. of blood given together with routine anti-shock treatment and 15 mg. of intravenous methedrine, the patient was considered fit to be transferred to the ward. A further 560 c.c. of blood and 400 c.c. of plasma were given by infusion at 50 drops per minute, and in six hours the blood-pressure rose to 100/88. Haemoglobin 80 per cent Haldane.

#### PROGRESS—

July 12. First re-dressing under gas and oxygen. The wound was quite clean. The through-and-through drain was taken out and the lower drainage tube left in. Blood-pressure 120/78. Haemoglobin 80 per cent Haldane.

July 19. All stitches had been removed by this date. A sulphanilamide powder dressing was applied, except in the lower part of the wound where there was a slight infection with *B. pyocyaneus*. This area was treated with  $\frac{1}{2}$  per cent acetic acid.

Aug 10. Wound completely healed. The patient was up and about on crutches, and was sent to see Mr. Langdale Kelham, of Queen Mary's Hospital, Roehampton. He gave the opinion that no satisfactory prosthesis was available for this extensive amputation.

X-ray Report (Aug 22). "The right side of the pelvis has been removed, except for a portion of the ilium

bordering on the right sacro-iliac joint. The parts removed include the whole of the pubic bone and ischium on the right side. The coccyx is deviated to the left."

## DISCUSSION

Certain points of technique are of considerable interest in an operation of this size. Gordon-Taylor (1935, 1940), who has recorded the largest individual series of cases, lays great stress upon certain precautions. He advocates adequate preparations for transfusion, gentle turning of the patient during operation, and sawing of the ilium rather than sacro-iliac disarticulation. He stresses the blocking of nerves before division and an incision such as Hogarth Pringle's (1916) modification of Girard's (1895) incision to give well-planned flaps with adequate blood-supply. We found the gluteal flap entirely satisfactory, but found it unnecessary to follow the detail of Assali and Sohler (1937). By using an oblique supine position for the patient, turning during the operation was avoided, though this advantage is also claimed by King and Steelquist (1943) for the lateral position. Subperiosteal dissection of the bulb is undoubtedly a time-saving manoeuvre where possible. Tidal drainage of the bladder overcomes post-operative retention, avoids distension, reduces risk of infection, and re-educates the bladder to perform its normal function. An obvious defect in the operation described is the double division of the femoral nerve and the gross shock caused by division of the femoral, sciatic, and obturator nerves within a few seconds of each other. This difficulty could be overcome by procaine injection of the nerves before division (Gordon-Taylor and Wiles, 1935).

The indications for an operation as radical as this are limited. Malignant disease involving the proximal portion of the thigh, hip, or innominate bone is the usual indication. It may very occasionally be considered in chronic osteomyelitis or tuberculosis of the hip which does not respond to conservative measures. It is unlikely to be of value in severe crushing or mutilating injuries such as those seen in war casualties, owing to the severe degree of shock already present.

We are greatly indebted to Mr. J. B. Hume for permission to publish this case, and for the help and encouragement which he has given to us in preparing this account. We should also like to express our thanks to Dr. G. T. Loughborough, of the Radiological Department, and to Dr. A. G. Stansfeld, of the Pathological Department, St. Bartholomew's Hospital.

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## SPONTANEOUS RUPTURE OF THE SPLEEN IN SARCOIDOSIS

By ILLTYD JAMES

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SPONTANEOUS rupture of an apparently normal spleen, although rare, is a well-recognized entity. The literature has been reviewed recently by Jones (1944), and previously by Hamilton Bailey (1930) and Susman (1927). The case to be described was considered to belong to this group until histological examination revealed the characteristic picture of sarcoidosis. Spontaneous rupture of the spleen in this disease has not hitherto been reported.

## CASE REPORT

**HISTORY**—J. B., a man of 49, was awakened on Sept. 20, 1944, by an 'alert'. Ten minutes later, while sitting up in bed, he had severe epigastric pain which

General examination was negative apart from the signs of chronic bronchitis. A pre-operative diagnosis of peritonitis of obscure origin was made.

**AT OPERATION**—Laparotomy revealed a large amount of fluid and clotted blood in the peritoneal cavity. The source of the bleeding was found at the upper pole of the spleen. Here there was a tear in the capsule from which blood-clot protruded. The spleen was not enlarged and was not unduly mobile. A blood transfusion was given and splenectomy performed. Examination of the other abdominal viscera revealed no abnormality.

The post-operative period was characterized by a pyrexia ranging from 99° F. to 102° F. No cause could be found to account for this, and after five weeks it returned to normal.

**THE SPECIMEN** (Figs 323, 324)—After removing blood-clot, a deep tear was found in the outer aspect of the upper pole. There were small subcapsular hæmatomas in the upper and lower poles. The capsule was



FIG. 323—Cut surface of spleen showing multiple hæmorrhages and tear in the capsule ( $\times 3$ ).

radiated to each iliac fossa. It was followed by vomiting which increased with the pain until his admission, 36 hours later. He gave no history of injury or of indigestion. A year before, he had been in hospital with pneumonia, and for 16 years he had been a victim of winter bronchitis.

**ON EXAMINATION**—He was a thin, pale, anxious-looking man. The pulse-rate was 96, temperature 99.6° F., respirations 22, and blood-pressure 120/90. The abdomen was rigid and tender all over. The liver dullness was normal, but shifting dullness was present in each iliac fossa. On auscultation there were normal peristaltic sounds and no transmitted sounds were heard. On rectal examination tenderness anteriorly was found



FIG. 324—Closer view of cut surface of spleen showing subcapsular hæmorrhage.

not thickened. The cut surface was brownish-red in colour, mottled by several hæmorrhages of varying size in the substance of the spleen. One of these involved the whole transverse diameter of the spleen and was undoubtedly the cause of the tear in the capsule by bursting through to the surface.

**HISTOLOGICAL EXAMINATION** (Figs 325-327)—The capsule does not show thickening or inflammatory changes except in an area where the splenic parenchyma appears to be replaced by extensive hæmorrhage. In this area there are remnants of trabeculae and one focus consisting of large epithelioid cells in the actual capsule. The rest of the splenic parenchyma shows rather atrophic pulp with large patent sinuses which are almost empty—containing only a few red blood-cells and some mononuclear elements. Most of the Malpighian corpuscles contain epithelioid cell nodules very much like miliary tubercles, but without proper caseation; instead there are deposits of hyaline material in the centre of some of these nodules. There are in addition a fair number of giant cells in these nodules. These are of the type of the so-called juvenile Langhans' cells, i.e., small in

# RUPTURE OF SPLEEN IN SARCOIDOSIS

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size and with the nuclei, small in number, often in the centre, or irregularly distributed throughout the cell. A feature of special interest is the presence of a fair number of nodules in the intima of large sinuses and veins. In many of these vessels a number of granulomata are present—in one lumen seven were found. It is worthy of note that in addition to the granulomata plas-matic fibrinous clots had formed in these vessels. Staining of the collagenous fibres shows some of the nodules with marked fibrous proliferation. In these sections it could be seen that the hæmorrhages were not confined to the subcapsular regions, but had involved parts of the actual splenic parenchyma, remnants of which were discovered in outline by means of stains for

Total serum proteins, 6.25 per cent  
 " " albumin, 3.8 per cent  
 " " globulin, 2.45 per cent  
 Blood Wassermann, negative  
 Repeated blood-cultures were negative

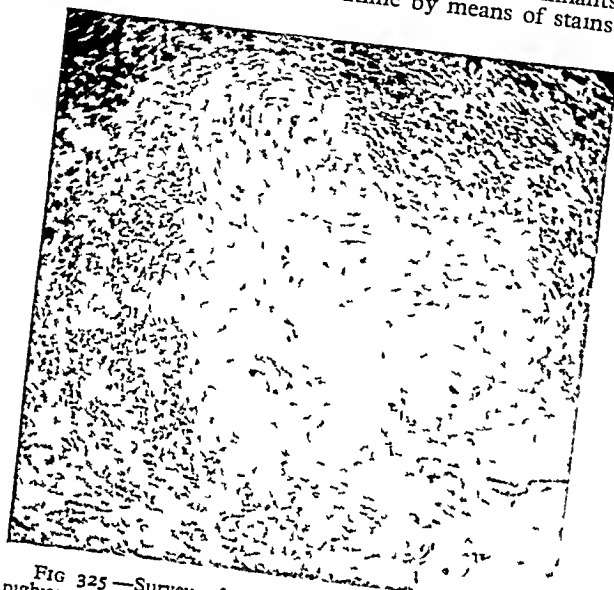


FIG 325—Survey of spleen showing a system of Malpighian corpuscles replaced by nodules of the Boeck type ( $\times 60$ )

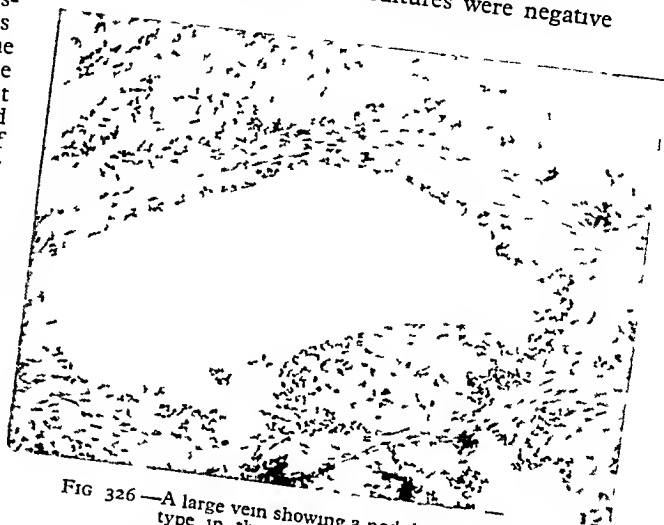


FIG 326—A large vein showing a nodule of the sarcoid type in the intima ( $\times 72$ )



FIG 327—A nodule of the sarcoid type with juvenile giant cells ( $\times 160$ )

elastic fibres. Acid-fast stains did not reveal the presence of tubercle bacilli. The histological features are those of non-caseating tuberculosis of the type of Boeck's sarcoidosis.

**SUBSEQUENT INVESTIGATIONS**—Although there were no clinical signs of the disease, the histological diagnosis of sarcoidosis stimulated a search for further evidence, with the following results—

**Lungs** The sputum was repeatedly negative for tubercle bacilli. Radiography showed a little enlargement of the hilar glands but no evidence of fibrosis of the lung parenchyma.

**Bones** X-ray examination of the phalanges, metacarpals, metatarsals, and the long bones showed no cystic areas and no osteoporosis.

**Eyes** The vision was 6/6 in each eye. No folliculoid formations were found in the iris or ciliary body and no nodules in the conjunctiva.

**Skin** No skin lesions were found.

**Lymph and Salivary Glands** No abnormality was found in the salivary glands and the lymph-glands that were palpable were not enlarged.

**Blood** Red cells, 5,160,000

White cells, 4000

Neutrophils,

51 per cent

Eosinophils,

4 per cent

Lymphocytes,

34 per cent

Monocytes,

11 per cent

Platelets, 180,000

Hæmoglobin, 77 per cent

Colour index,

0.75

Sedimentation rate, 50 mm in 1 hour

(This rise in sedimentation rate a month later had fallen to 15)

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Mantoux reaction 1/10,000, 1/1000, 1/100, were all negative, 0.01 mg of vole bacilli (an avirulent acid-fast strain occurring in tuberculosis of voles) was injected intradermally, and after an interval of six weeks the Mantoux test was repeated. It remained negative. This is in conformity with the work of Lemming (1940), who found that BCG injection would fail to turn a negative Mantoux into a positive one in patients with Boeck's sarcoid in contrast to ordinary Mantoux-negative persons.

**Subsequent History of the Patient**—The patient has been kept under observation for nine months. He has remained in good health since the operation and has not developed any clinical or radiological evidence of sarcoidosis. His blood-sedimentation rate is now 3 mm in 1 hour and his blood-count is within normal limits.

## DISCUSSION

Sarcoidosis is a disease which affects mainly the reticulo-endothelial system, with the formation of follicles resembling those found in tuberculosis, but with no tendency to caseation. The lungs, lymph-glands, liver and spleen, skin, and the small bones of the hands and feet may be involved together or in various combinations. The course is protracted, with continued fever and usually a high sedimentation rate, but the disease tends to regress spontaneously, the lesions healing by hyalinization and fibrosis. Although there is a close resemblance to tuberculosis, the lesions do not caseate, acid-fast bacilli are not found, and the Mantoux reaction is usually negative. The Mantoux reaction remains negative in spite of sensitization either by heat-killed tubercle bacilli or by live avirulent acid-fast bacilli. In a normal person these would convert a negative Mantoux into a positive one.

Splenomegaly is often a prominent feature and was present in 7 out of 13 cases reviewed by Snapper (1938). Although the splenomegaly is often of secondary importance when the disease is generalized, it may be obtrusive enough to warrant splenectomy, as reported recently by Cameron and Dawson (1942). Punctate hæmorrhages throughout the substance of the spleen were found in their case. In our case similar hæmorrhages were present, and

it is probable that they are caused by the vascular changes, including the tendency to thrombosis already described. When a vessel of suitable size is involved the hæmorrhage may be sufficient to rupture the capsule of the spleen, causing intra-peritoneal hæmorrhage.

## SUMMARY

A case of sarcoidosis with spontaneous rupture of the spleen is described. No involvement of the other organs was found. The underlying pathology was found only on microscopical examination of the removed spleen.

We are indebted to Dr E Nassau for obtaining the vole bacillus, and to Dr Walter Pagel for the pathological investigations and for his criticism and advice.

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## THE MEM SPHYGMOSCOPE IN VASCULAR INJURIES\*

By F BARNETT MALLINSON

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ANÆSTHETIST TO E M S

AND DENYS O WILLIAMS

ASSISTANT SURGEON TO E M S

In the work of a Vascular Injuries Centre we have found that serial blood-pressure readings are often a great help in determining the actual vessel involved in a traumatic false aneurysm or arteriovenous fistula, in assisting to estimate the size of the hole responsible for an arterial leak, in providing some guide to the progress of the development of the collateral circulation before and after any ligature operation, and finally in demonstrating the degree of patency or otherwise of an artery after a suture operation.

The signs elicited by ordinary clinical examination of a patient suffering from an arterial lesion are sometimes misleading. For instance, the presence of a swelling and a full cycle murmur and thrill in Scarpa's triangle may suggest an arteriovenous fistula between the superficial femoral vessels when actually the profunda vessels are involved. By recording the blood-pressure in the limb distal to the lesion a correct diagnosis can often be made, for should the pressures be only slightly below those in the same segment of the normal limb it is probable

that the profunda vessels are involved, but should the pressures be much impaired the lesion probably affects the superficial vessels. Similarly, a wide fistula between main limb vessels is found to produce a bigger drop in pressures beyond the lesion than a narrow one, and with the knowledge of these pressures one is frequently enabled to foresee unexpected difficulties at operation and plan accordingly. The diagnosis, however, is also influenced in varying degree by other factors, such as the effect on the pulse-rate of obliteration of an arterial leak, but a recording of the blood-pressures is, nevertheless, important.

Various factors combine to limit severely the applicability of the usual auditory method of blood-pressure estimation in this work. Amongst the most important may be mentioned—

1 The need in many cases for taking the measurements on the distal segment of the limb, where no satisfactory artery for auscultation exists.

2 The frequent presence of so loud a murmur as to make auditory estimation impossible, even where an artery is easily available for auscultation.

A visual method is thus essential in many cases. There are various forms of oscillogram which give visual indications, and probably the best of these

\* Read at a meeting of the Vascular Injuries Subcommittee of the Medical Research Council on March 27, 1945.



machines is the Recklinghausen oscillotonometer (von Recklinghausen, 1906, 1907) We have used one but found it insufficiently consistent and reliable Amongst its outstanding disadvantages were —

1 So-called 'edge effects', when estimating systolic pressure These are small oscillations due to the impinging of the blood-stream impulses against the edge of the upper cuff, which appear before the true oscillation and vitiate the accurate determination of its appearance

2 The difficulty of estimating accurately the amplitude of the oscillations of a pointer moving round a scale

3 The impossibility of estimating really low diastolic pressures with any degree of accuracy

4 The wide margin of error generally, shown by the inconsistency of rapidly consecutive readings

The apparatus was therefore abandoned and trials were instituted with the latest apparatus for visual estimation of blood-pressure—the M E M sphygmoscope

This machine and its principles have been fully described by Evans and Mendelssohn (1942) and Mendelssohn, Evans, and Mallinson (1943, 1945) Briefly, two cuffs are employed (*Fig 328, S, D*)

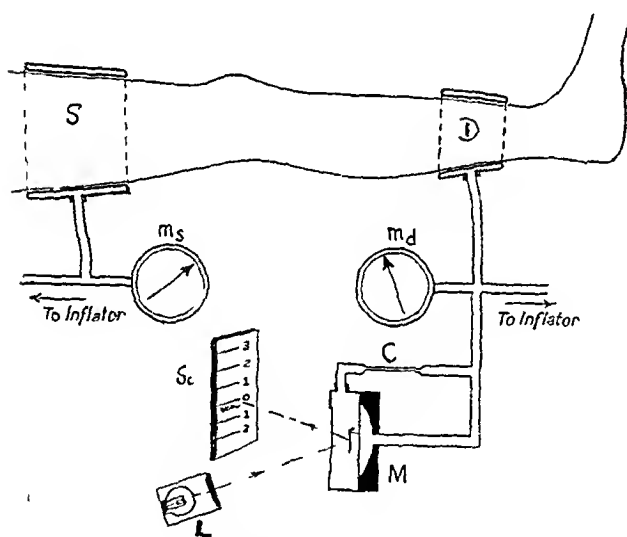


FIG 328—Diagrammatic representation of the M E M sphygmoscope

Each is connected to an aneroid manometer (*Ms, Md*), which records the pressure in it in mm Hg Each cuff can be inflated independently A highly sensitive membrane manometer (*M*) is connected only to cuff *D* This manometer *M* carries a mirror which reflects a bar of light from a source (*L*) on to an illuminated and graduated scale (*Sc*) Thus any pulsations in cuff *D* are greatly amplified and clearly and faithfully reflected on the scale *Sc* The two chambers of the manometer *M* on each side of the membrane are connected by a capillary (*C*) to ensure that both are at the same mean pressure

If the distal cuff *D* is inflated to a pressure above diastolic but below systolic pressure, relatively large, sharp, and jerky oscillations will be received by the manometer *M* from the cuff *D* and reflected highly

amplified on the scale *Sc* The character of these oscillations is as described because the artery beneath the cuff is completely collapsed in diastole owing to the pressure in the latter being above the diastolic pressure in the former If now the pressure in *D* is slowly released there comes a point at which an abrupt change in the character of the oscillations observed occurs The pulsations are reduced in size by nearly 50 per cent and become smoother and more gentle The reason for this is that the pressure in the cuff *D* is now at or below the diastolic pressure in the artery and the latter does not collapse in diastole but pulsates in an even and elastic manner with the now continuous flow of blood through it The point of change in the character of the oscillations is the diastolic end-point and can be read on the manometer *Md*

If the proximal cuff *S* is now inflated (leaving cuff *D* at any convenient pressure below diastolic) to a pressure above systolic, no impulses at all can reach cuff *D* and the light bar remains motionless If cuff *S* is now slowly deflated, at a certain point pulsations will again commence to reach cuff *D* and will be reflected as oscillations of the light bar on scale *Sc* This occurs at the point at which the pressure in cuff *S* is at systolic pressure, and thus the systolic pressure can be read on the manometer *Ms*

The light bar oscillates always over the same area of the stationary scale *Sc*, thus enormously facilitating accurate observation Controls (not shown in the simplified figure) on the apparatus provide for slow and perfectly even release of pressure, which can be instantaneously checked at will Thus the readings of pressure can be made on the manometers *Ms* and *Md* while their needles are held stationary at the estimated end-point, thus further lessening the possibility of error

Using this apparatus on a considerable number of patients suffering from traumatic aneurysms, arteriovenous fistulae, and other arterial lesions, we have found it very easy to read The systolic end-point is very sharp, vibration due to murmurs is minimal, and the diastolic end-point is much more definite than hitherto This last has been particularly evident in estimating really low pressures

Measurements in the region of 50/40 mm Hg (measurements previously found to be virtually impossible) have presented little or no difficulty The consistency of readings is very high, as has been repeatedly demonstrated by one of us checking the other's measurements immediately, but without having previous knowledge of them The discrepancy has never been more than 2–3 mm Hg

Estimations can be made just as easily on the forearm or lower leg as on the upper arm or thigh

Although it is possible that the actual figures obtained may not be those of the actual arterial blood-pressure, they are at the very least as accurate as with auditory methods, and certainly more accurate than the latter in respect of the diastolic pressure, the end-point of which is still controversial to-day, and in any event the exact value is immaterial For clinical purposes it is the reliability and consistency of the observations of the rise and fall of pressures which is really essential, and in this respect the M E M sphygmoscope has been found to be excellent

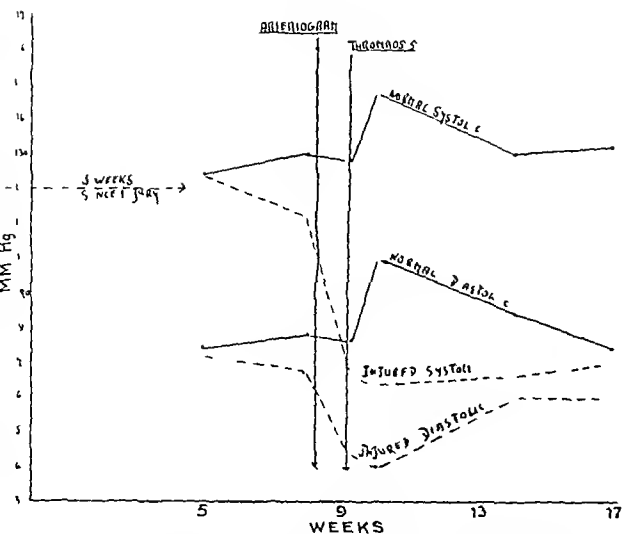


FIG 329—Case 1, J C, aged 35 Effect of thrombosis of popliteal artery and sac of false aneurysm, following injection of pyelectan for arteriography

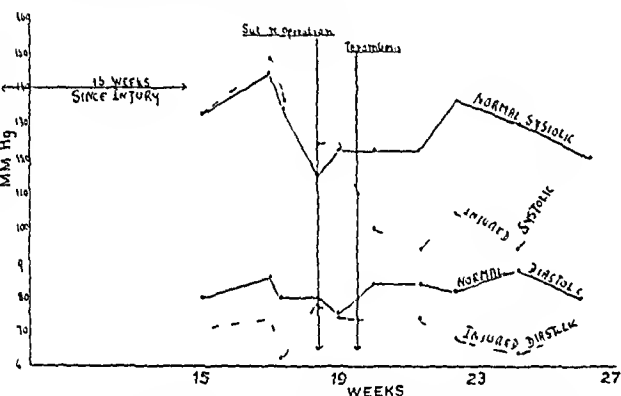


FIG 332—Case 4 P A, aged 19 Effect of thrombosis seven days after suture operation for a popliteal varicose aneurysm. Repair necessitated two separate suture lines on artery, thus adding to danger of subsequent thrombosis

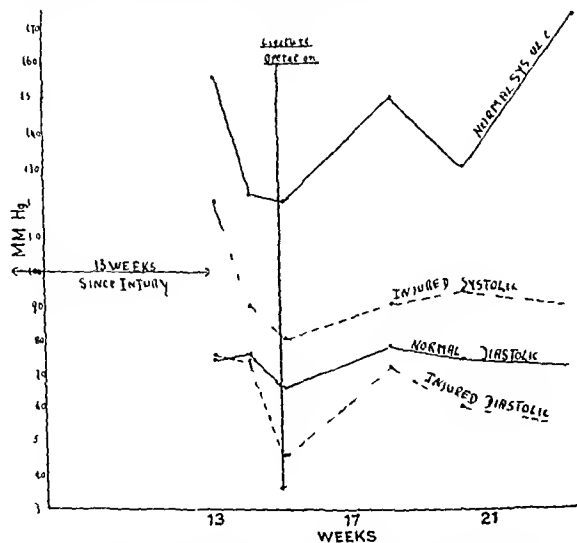


FIG 333—Case 5 F H, aged 19 Immediate increase in fall of pressures after ligature operation for a false aneurysm at junction of superficial femoral and popliteal arteries

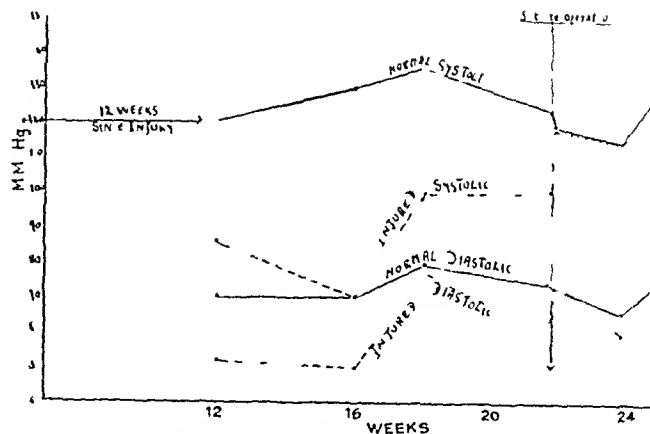


FIG 330—Case 2, J T, aged 19 Restoration of blood pressures in distal segment of limb to approximately normal, following successful suture operation for a popliteal varicose aneurysm

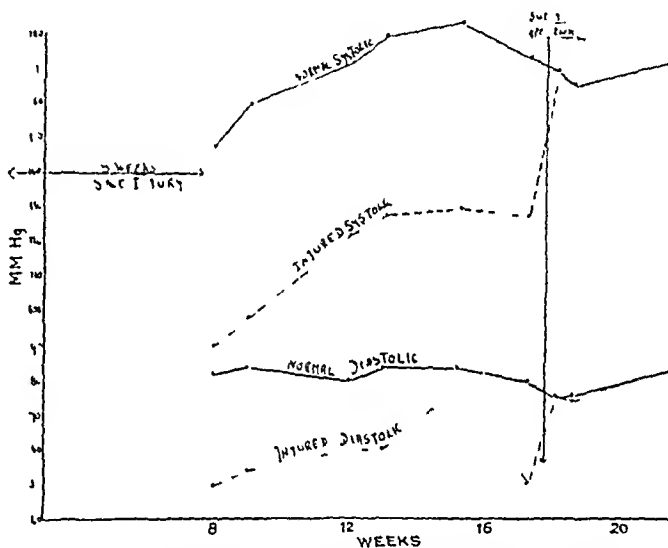


FIG 331—Case 3, A L, aged 18 Result of successful suture operation in a varicose aneurysm of the superficial femoral vessels. Large hole found in artery at operation, hence big difference in pressures before operation

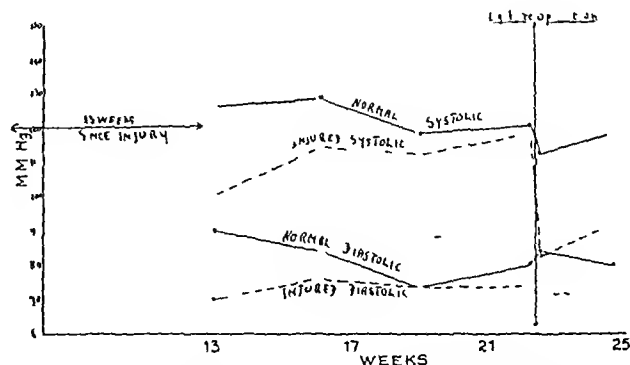


FIG 334—Case 6, F H, aged 21 Shows gradual rise in pressures associated with development of collateral circulation in a case of varicose aneurysm of the first part of the axillary vessels, and subsequent drop after ligature operation

The accompanying charts (Figs 329-334) are illustrative of the type of work done on these cases with the apparatus

### SUMMARY

Serial blood-pressure readings are of considerable assistance in the field of vascular surgery, and trials with the M E M sphygmoscope have shown it to possess the following advantages over other methods of estimating them —

1 Both systolic and diastolic pressures are clearly and easily estimated *visually*

2 Measurements are made just as easily on either upper or lower limb and on any part of them

3 Measurements of very low pressures, particularly with low pulse pressures, present little or no difficulty

4 Independent readings show a high degree of consistency

Our grateful thanks are due to Mr B C Maybury for much valuable help and advice, and to Mr B C Maybury, Mr A Innes, Mr C P Sames, and Mr J White for permission to obtain material for charts from the cases under their care

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## THE RELATIVE INCIDENCE OF STERNOMASTOID AND OCULAR TORTICOLLIS IN AIRCREW RECRUITS

By J GRIEVE, SQUADRON-LEADER, R A F V R

OCULAR torticollis can be broadly defined as a tilting of the head occurring in association with hyperphoria. On this basis a wide range of head tilting and of hyperphoria is possible. Binocular vision and facial asymmetry may or may not be present, but in all cases the conjugate ocular movements are abnormal. Professor Mann (1944) does not consider that all cases falling in the above classification should be labelled as ocular torticollis. She states that, "to diagnose true ocular torticollis we have considered that the tilt should be present all the time and should be practically lifelong, that the movements should be abnormal, that a vertical squint should be apparent with the head erect, and that the patient should be binocular only in the tilted position." Those not fulfilling these criteria are classed as head tilting associated with hyperphoria.

The present series includes both Professor Mann's categories. In every case the head tilt was constantly present, and was one of the features drawing attention to the condition.

Most surgical text-books devote a section to sternomastoid torticollis, but dismiss the ocular variety in a few words. Lyle and Jackson (1940) state that sternomastoid torticollis is considered to be more common, while in the latest edition of Mercer's *Orthopaedic Surgery* (1943) only passing reference is made to an ocular aetiology. In the course of examining 9500 recruits for flying duties 2 cases of sternomastoid and 16 of ocular torticollis have been found. No spasmodic cases have been seen. The group examined had a mean age of 21 years, with a standard deviation of the order of 4.5 years. The only definite selective factor at work was the preference for flying duties expressed by these young men.

### FEATURES OF THE CASES

**Sternomastoid**—Both were typical, the one showing a head tilt of 10-15° and the other 20°

The facial asymmetry was more marked in one than the other.

**Ocular**—In this group the degree of head tilt varied between 5° and 15°, and the hypertropia ranged from 2.5 to 20 prism dioptres or more. Three of the ocular cases showed definite facial asymmetry, and all had abnormal conjugate movements. One case, described below, demonstrates the importance of differential diagnosis.

**Case**—H M, aged 18½ years, was a draughtsman who had always had a head tilt of 10-15° to the left. Nothing was known of his obstetric history, and, so far as he knew, the head tilt had always been present. Six years previously he had had a tenotomy of the left sternomastoid, but no benefit resulted.

**ON EXAMINATION**—There was a 10-15° head tilt to the left with a mild degree of facial asymmetry. The tilt could be corrected voluntarily. His visual acuity was 6/6 in each eye, and the cover test showed that he had a marked R/L vertical squint—in fact, the right eye suppressed and could not be depressed below the horizontal. No reading could be obtained on the Maddox rod or the Maddox wing, and it was impossible to demonstrate any stereoscopic vision using the Livingston rotating stereogram. The conjugate ocular movements were distinctly abnormal.

### DIFFERENTIAL DIAGNOSIS

This has been fully described by Lyle and Jackson (1940), and is best summarized in tabular form (*Table I*).

It will be seen from this that if the possibility of an ocular basis is not considered, there is a strong possibility that an ocular torticollis might be treated as a sternomastoid, as happened in the case described above.

### DISCUSSION

So far no clue has been found as to the reason for the general belief that a sternomastoid torticollis is much commoner than the ocular variety. One

Table I—DIFFERENTIAL DIAGNOSIS OF STERNOMASTOID AND OCULAR TORTICOLLIS

DIFFERENTIAL FEATURE	STERNOMASTOID	OCULAR
1 Head tilt	Obvious	Not so obvious
2 Sternomastoid	Contracted	Not contracted
3 Head position	Not possible to straighten passively	Passive straightening possible
4 Position of face	Away from side of tilt and looking up	Towards side of tilt and looking down
5 Conjugate ocular movements	Normal	Abnormal
6 Extrinsic ocular muscle balance	Good	Shows hypertropia or hypotropia
7 Facial asymmetry	Marked	Less marked or absent

possible explanation of the present reversal of the ratio is that the incidence of 'sternomastoid tumours' is declining as the result of improved obstetrics, while more cases of ocular torticollis are being recognized. The sufferer from an ocular torticollis can correct his deformity at will, and, in the absence of a detailed ocular examination, is more likely to be missed than is the sufferer from a sternomastoid contracture.

A ratio of 8 ocular to 1 sternomastoid torticollis discovered in examining nearly 10,000 young adults seems most unlikely to be due to chance. Further information has been obtained relating to the incidence of torticollis in general. Among 11,805 orthopaedic cases seen in the 10-year period 1929-1938 at clinics run from the Wingfield-Morris Orthopaedic Hospital, Oxford, 111 cases of torticollis of all kinds were seen. This figure comprised 108 sternomastoid cases, 1 spasmodic case, and 2 hysterical cases. No case of ocular torticollis has been seen. In 1944 at the Oxford Eye Hospital 18 cases of ocular torticollis conforming to the general description were seen, while at Reading Eye Clinic, out of 6979 cases seen in 1938-40, 17 cases of torticollis occurred—2 sternomastoid and 15 ocular. These findings are summarized in Table II.

The most interesting feature of this table is the close similarity between Squadron-Leader Cashell's figures at Reading and those of the present series.

This may well be chance in view of the fact that the cases at Reading were a much more selected group. It seems appropriate, however, to draw attention to ocular muscle imbalance as of more than academic interest in the aetiology of torticollis. In the absence of a readily demonstrable sternomastoid contracture, a careful examination of the ocular muscle balance is indicated.

### SUMMARY

In the course of examining 9500 recruits for fitness for flying duties, 2 cases of sternomastoid torticollis have been found and 16 cases of ocular

Table II—INCIDENCE OF TORTICOLLIS

CLINIC	TOTAL CASES	TORTICOLLIS			
		Sternomastoid	Spasmodic	Ocular	Hysterical
Wingfield Morris, 1929-1938	11,805	108	1	0	2
Oxford Eye Hospital, 1944	6,902	0	0	18	0
Reading Eye Clinic, 1938-1940	6,979	2	0	15	0
Present series	9,500	2	0	16	0

torticollis. A possible explanation of this reversal of the usually accepted ratio of the two conditions is advanced, and a plea is put forward for the better recognition of ocular muscle imbalance as an aetiological factor in torticollis.

I am indebted to the Director-General of Medical Services for permission to publish the Royal Air Force material, and to Professor Ida Mann, Professor H J Seddon, and Squadron-Leader G T W Cashell for putting their records so freely at my disposal.

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## In Memoriam

JAMES SHE

(1872-194)

WITH the death of James Sherren, at the age of 73, there passes one of the great figures of English surgery, a man of strong character, of great ability, and an attractive personality. His life was one of adventure, of hard work, of romance, and of unusual and rapid success.

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mate in one of the great shipping lines. Before he had gained a ship of his own, however, he suddenly decided to leave the sea and to enter the medical profession. What dominant factor compelled him to make this unusual decision is unknown, his action was apparently as sudden and determined as was his decision in later life to abandon surgery at the height of his career and at a moment's notice. He never lost his love of the sea. In more confidential moments he delighted to recount the hardships of his early life and the adventures of his various trips. Nor did he lose his interests in ships, his knowledge of which was encyclopædic, so that at a moment's notice he was able to tell one the position and date of sailing of any ship.

In the profession of surgery his career had no setbacks. He qualified at the London Hospital in 1899 and took the F.R.C.S. the next year. Three years later he was appointed Assistant Surgeon while still only 30 years of age—a record of rapid progress which has remained unbroken. During his period as Surgical Registrar he was a driving force to all his students, he knew them all and controlled their work and note-taking with strict discipline, so that we all feared his frequent rounds and the short and forcible notes left in his wake, but we all recognized his ability and his justice and rejoiced on his appointment to the staff. Incidentally, his quick progress and the success dependent upon his great ability is even now a strong argument in favour of having a portal of entry into medicine which is non-academic. If it had been necessary for Sherren to pass through a university, surgery would probably have been robbed of one of its leading lights.

Perhaps he was fortunate in having started the practice of surgery at the time of its most rapid development, but his strong and forceful character would have led to speedy advance in any profession. His knowledge of his subject was wide and detailed and his conclusions always definite. There was never in his mind any doubt of the line to be pursued, and his clear exposition, his confidence, and his manual dexterity made him a popular teacher and soon brought him a great reputation. In addition, he showed a clarity of thought in research which, when directed, in conjunction with the late Sir Henry Head, to the subject of the distribution of sensory nerves and the treatment of nerve injuries, gave him world-wide fame. Later his interest focused on abdominal surgery, and it is as one of the pioneers of modern gastric surgery that he will be remembered. His leadership and his operative ability in this branch were shown by the fact that his theatre was always filled with visiting surgeons from every country. His private practice grew rapidly, but he never allowed it to interfere with his hospital work. At this time I not only had the good fortune to be his hospital Registrar, but also acted as his private assistant and soon learnt to have a great admiration for his work. As a man one of the most impressive points in his character was the change from his rather abrupt manner to one of the greatest gentleness and kindness when talking to an ill patient. Never in his whole career was he late for any appointment. He worked rapidly

and neatly, but although he was quick and decisive, there was never any haste or flurry. He always gave the impression that he knew precisely what he was going to do and set out to do it with speed and efficiency.

Professional recognition and honours came to him quickly. Erasmus Wilson Lecturer in 1906, he was elected to the Council of the Royal College of Surgeons in 1917, being Hunterian Professor in



JAMES SHERREN  
(1872—1945)

1920 and Bradshaw Lecturer in 1925. He served for two years as Vice-President of the College. In the last war he was Consulting Surgeon to the War Office and Colonel, A.M.S., at this time doing the greater part of the surgical work at the King Edward VII Hospital for Officers. He was Examiner for Surgery at London University and for Anatomy in the Primary Examination for the F.R.C.S., and he was also a Member of the University Senate.

Then, in 1926, when at the height of his fame and career, when he had gained a reputation, not only in England but throughout the civilized world, which he shared only with Lord Moynihan, and when his way was clear to even higher honours, he suddenly announced his intention to retire. Within a few days he had resigned from the Council and from the London Hospital, had sold his house and cars and had severed all his professional connexions. Just as his entry in medicine, so was his retirement. What was the overwhelming urge

no one knows probably he felt again the call of the sea and was determined to answer it while still of an age to enjoy it. More than most he must have felt—

"I must go down to the sea again, the lonely sea  
and the sky  
And all I ask is a tall ship, and a star to steer  
her by"

He could at any rate leave surgery with the satisfaction of knowing that seldom if ever had any man accomplished so much and advanced so far in the short thirty years he had devoted to it.

Returning to his place in the country overlooking Poole Harbour and the sea he loved, he found that even here he was unable to rest on land, and he went back to work as a ship's surgeon, where his great reputation enabled him to do much to better the conditions of the Marine Medical Service.

Sherren was a man who owed his advancement to sheer ability and strength of character, and although of a naturally shy and retiring disposition so that he hated making a public speech, he always stood out by the honesty of his work and the

reliability of his opinions. In spite of his discipline and of his scorn of slackness which made him feared by those who did not know him, he soon endeared himself to those who had the privilege of working under him. With his death there is lost to us a great surgeon, a fine and romantic figure of a man, and a lovable personality. His name will rank high even on the distinguished roll of Dorset men. While England breeds such men her position in the mercantile marine and in surgery remains assured. Sherren has made his last voyage, but if it be true, as Confucius says, and as I think we all believe, that "Our bones shall moulder and rot in the fields, but the spirit issues forth and lives on high in a condition of marvellous brightness", then it is permissible to believe, nay, it is indeed probable, that the soul of this great man, this brilliant surgeon, and this fine character is not dead, but—

" has only passed  
Further along a road whose sudden bend  
Awhile has hid him from us, till at last  
We reach our journey's end"

## SHORT NOTES OF RARE OR OBSCURE CASES

### A CASE OF SARCOMA OF THE LIVER

By F. D. SANER

SURGEON, ROYAL NORTHERN HOSPITAL

THE following case may be of interest since it presents one or two unusual features.

#### CASE REPORT

**HISTORY**—R. P., a man aged 59. Except for operations as an infant to close a cleft lip and palate, this man gave no medical history, according to his statement.

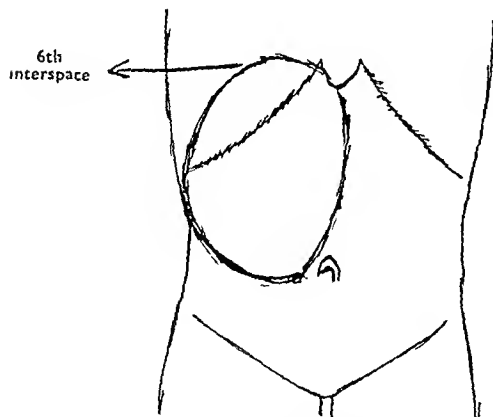


FIG. 335.—Diagram showing approximately the size and position of the tumour.

he had enjoyed good health and led an active life until the onset of the present condition.

About the autumn of 1943 an increasing lassitude was noticed associated with gradual loss of weight and

nocturnal frequency of micturition. During the spring of 1944 the abdomen began to swell and the bowels at this time were acting about a quarter of an hour after each meal, when the stools were bulky, very pale, and offensive, the appetite, however, remained good. Later, during July, swelling of the legs and ankles became marked, and this, together with increasing pain on lying on his back or right side, finally resulted in a decision to seek advice.

**ON EXAMINATION**—The patient was tall and of spare build, with marked pallor of the face, breathlessness, and obvious loss of weight, the size of the abdomen and the swelling of the legs were immediately apparent.

A large tumour was found filling the upper right quadrant of the abdomen. The tumour, oval in shape, firm, smooth, rounded, and apparently solid, extended from above the costal margin to just below the umbilicus and back towards the loin (Fig. 335). On deep respiration the tumour moved over towards the left of the mid-line. Neither at the initial nor subsequent examinations was any evidence found of growth elsewhere.

Other investigations made were—

Blood-sugar, 0.165 per cent  
Blood-urea, 32 mg per 100 c.c. of blood  
Hb, 52 per cent C.I., 0.56  
R.B.C., 4,650,000 per c.mm.  
W.B.C., 5600 per c.mm.

Lymphocytes 18 per cent, Eosinophils 8 per cent

Polymorphs 66 per cent, Basophils 0

Large mononuclears 8 per cent

Anisocytosis and poikilocytosis present, moderate

No nucleated R.B.C.

Urine S.G. 1020, acid, faint trace albumin, otherwise normal. All glandular areas normal. Heart and lungs, C.N.S., limbs nothing of note.

**LAPAROTOMY** (Sept 21, 1944)—Right paramedian incision. When exposed, the mass had the dull whitish appearance of a thick-walled cyst, with numerous blood-vessels covering its surface, arising from the under surface of the left lobe of the liver. An exploratory needle was inserted into the tumour but nothing withdrawn, the wall, therefore, was incised, when a large quantity—about 25 oz—of soft grey, friable tissue, somewhat resembling brain tissue, escaped, while the bleeding from the wall of the tumour was moderately severe. At this stage the patient was showing signs of shock, but after a pause while an intravenous plasma drip was commenced the condition improved. The wall of the tumour was separated from the structures of the posterior abdominal wall and finally delivered through a large opening in the gastro-hepatic omentum, which was tightly stretched over the mass, with the stomach pushed well over to the left of the abdomen. It was then found that the whole of the left lobe of the liver was involved, with a thin layer of liver substance (about  $\frac{1}{2}$  of an inch) covering the dome of the tumour and a bridge of liver substance between this and a normal right lobe of the liver (Fig 336). This bridge was



FIG 336—Photograph of tumour laid open. A, Layer of liver substance.

divided by means of a diathermy knife and the raw surface of liver closed so far as possible by means of catgut sutures. The opening in the gastro-hepatic omentum was repaired and after a rapid survey for any evidence of a possible primary growth, of which none was found, a drainage tube was inserted and the abdomen closed. A quite uneventful recovery was made and the man left hospital on the twenty-fifth day after operation.

**PATHOLOGICAL REPORT**—The following report was made by Dr P O Elhson, who has, too, kindly added a footnote on the condition. Tumour of the liver. Soft and white. Weight 68 oz (this included most, but not quite all, of the contents of the tumour). A large, soft, rounded tumour, embedded in the liver, no obvious capsule but no visible sign of infiltration. The small portion of liver present shows no sign of cirrhosis and looks healthy (Fig 337).

**Microscopical** Histologically this is a classical example of spindle-celled sarcoma—with its elongated cells and vascular clefts—of an actively growing type.



FIG 337—Photograph of tumour showing its gross structure.

It has no capsule. The liver tissue is little affected, being slightly compressed near the growth.

*Note*—Massive, solitary neoplasms of the liver, although perhaps not of extreme rarity, are decidedly uncommon, they are almost invariably malignant, and this specimen is undoubtedly so. Mere size is an insufficient guide as to whether the growth is primary or secondary, and though multiple growths would be expected if the tumour were a secondary, yet cases are on record of solitary massive sarcomas of the liver.

This growth appears to be a pure spindle-celled sarcoma, though, according to Ewing, a true spindle-celled tumour of uniform structure has yet to be reported (Ewing's *Neoplastic Diseases*, 4th ed).

It is true that the vascularity of the growth described above might suggest a diagnosis of angiosarcoma, but the conspicuous histological feature is the solid spindle-celled structure.

**PROGRESS**—During March, 1945, R P wrote to say that until mid-February he was making satisfactory progress, but then an attack of influenza had put him back and progress since then had been retarded. His main complaints, he wrote, were breathlessness and pain in the chest after walking or going upstairs, also that he was easily tired and latterly had gained no weight, on the other hand, he said he suffered no pain, was eating and sleeping well, that there was only very slight swelling of the ankles and feet, and the stools though rather light in colour were otherwise normal.

At the end of March he came to report personally, when again his pallor was a striking feature. On general examination nothing abnormal was detected except at the upper end of the laparotomy scar. In this position there was a small rounded moveable tumour immediately subcutaneous which was said to have appeared suddenly.



three weeks previously, it was slightly larger and thicker than a sixpence and gave the impression of being semi-solid. Re-admission to hospital was advised with a view to treatment of the anaemia and for removal and examination of the small tumour. The blood-count was as follows—

R B C,	3,300,000 per c mm
Hb,	40 per cent
C I,	0.6
W B C,	6800 per c mm
Polymorphs,	77 per cent
Lymphocytes,	15 per cent
Eosinophils,	5 per cent
Basophils,	1 per cent
Large mononuclears,	2 per cent
Anisocytosis and poikilocytosis marked	
Normoblasts,	34 per c mm

The small tumour of the abdominal wall when removed was mainly composed of soft, friable, greyish-looking tissue on which Dr Ellison reported that "a small proportion of the tissue consists of spindle-celled sarcoma."

After two weeks in bed under treatment (Dr E G B Calvert) the patient had gained in weight and had considerably improved in appearance. On the seventeenth day after admission he complained of pain, though not severe, across the upper abdomen, was rather restless, and had depreciated again in appearance, nothing was found on examination. The next day there was an obvious though not copious melaena, soon after which the pulse started to fail and the pallor increased, R B C, 1,200,000 per c mm. Hb, 20 per cent.

Death occurred some twelve hours later. Unfortunately a post-mortem examination was refused.

## RUPTURE OF AN AXILLARY ANEURYSM THROUGH THE QUADRILATERAL SPACE\*

BY LIEUT.-COL. J. J. MASON BROWN, R A M C

OFFICER IN CHARGE, FIELD VASCULAR CENTRE, C M F

MAJOR G. L. FENCLEY, R A M C

ANÆSTHETIC SPECIALIST

AND CAPT. N. C. WELPLY, R A M C

RESUSCITATION OFFICER

THE following case seems worthy of record not only because of its rarity but also because of its great interest from the viewpoint of the treatment of severe blood loss and shock.

### CASE REPORT

The patient, R. W., aged 18 years, a German prisoner of war, was admitted to the Field Vascular Centre on Jan. 18, 1945.

**PREVIOUS HISTORY**—He was wounded by machine gun on Jan. 7 in the right shoulder and right lower jaw. Bleeding from one of the shoulder wounds was profuse and he lost consciousness. Before losing consciousness he noticed that he was unable to dorsiflex his right wrist.

At C C S, six hours after wounding, he was found to have (1) Through-and-through wound of the right lower lip, with fracture of the mandible, (2) Entry wound to the right of the manubrium sterni and exit wound just lateral to the body of the right scapula. Anti-gas-gangrene serum and penicillin were given and a plasma drip was commenced.

Five and a half hours later, B P 120/80. Blood transfusion (1 pint) begun. Radiography shows foreign body at apex of lung and comminuted fracture of body of right mandible from 3/ back to 8/ which is involved on a separate fragment.

Operation, 29 hours after wounding, at Forward Facio-maxillary Unit. (1) Wounds of right hand incised and fragments of clothing removed. (2) Wounds of right sternoclavicular region and scapular region incised. Track disappeared deep to right clavicle. Slight hæmorrhage controlled by gauze and firm bandage. (3) Submandibular incision, loose bone fragments removed, drains inserted. Eyelets and I M F.

On Jan. 9 swelling of right arm noted.

Jan. 11, 7543/ extracted and upper and two-piece lower splints applied with I M F wires and elastic traction.

Jan. 12, 1945, 5 days after wounding, marked œdema of right arm and continuous thrill over the pectoral muscles (R). Tube for penicillin to anterior neck wound and 10,000 units instilled daily for three days.

**ON ADMISSION** to Field Vascular Centre, 11 days after wounding—The right arm is grossly œdematous from the base of the fingers to the axilla. A continuous thrill is easily felt in the right infraclavicular area and is conducted over the upper chest wall, but not down the arm. Above the clavicle there is a thrill during systole only. The right subclavian artery is more easily felt and its pulsations more forcible than on the left side. There is a loud systolic murmur and a continuous rasping bruit maximal just below the clavicle and conducted proximally along the subclavian artery and along the carotids on both sides and distally to the cubital fossa. The right radial pulse is slightly diminished and is delayed. The skin of the right hand shows some rubor, but there are no other trophic changes. The hand is warm even after exposure to room temperature.

The heart is of normal size. No abnormal findings. P 92, B P 135/90.

#### Blood Examination—

Blood group, B III. R B C 3,600,000  
Hb = 98 per cent. S = 12.15 g. per cent = 84 per cent H.

C I = 84/72 = 1.17. W B C 12,000  
B S R (47) corrected = 30 mm in 1 hr.  
Hæmatocrit 38 per cent.

Mean corpuscular volume = 106 cu. micra.

Mean corpuscular Hb = 34 mg.

Mean corpuscular Hb conc. per cent = 32 per cent.

Coagulation time = 3½ min.

It was considered that there was an arteriovenous lesion of the first part of the axillary artery and that the circulation to the upper limb was adequate for its resting needs. The œdema might be due to the result of the initial ischaemia or to venous obstruction. As there was no obvious sign of sepsis in the wounds it was hoped that conservative treatment would be followed by the development of a good collateral circulation.

\* From a General Hospital, C M F.

uncomplicated by secondary hæmorrhage. Peripheral nerve examination revealed a lower trunk brachial plexus lesion.

The œdema of the arm subsided steadily, but on Jan 23 he became febrile. There was impaired percussion note with vesicular breath-sounds accompanied by crepitations at the right base. Sulphathiazole course begun.

The temperature subsided, but on Jan 30, i.e., 23 days after wounding, there was a slight hæmorrhage from the wound over the right scapula posteriorly. This was treated by firm dressings only as there was no swelling in relation to this wound and no pulsation while the axillary signs were unchanged.

On Feb 1 there were two very slight hæmorrhages from the posterior wound, but again no pulsation or murmur.

On Feb 2, at about 00.05 hr, there was a further hæmorrhage, again of small size, from the posterior wound. Under pentothal (G. L. F.), and with a plasma drip running, the wound lateral to the axillary border of

muscles were divided and the costocoracoid membrane divided, exposing the wall of the false aneurysm and the grossly dilated vein obscured by fibrous tissue. The axillary artery distal to the lesion was of small size and was cleared and temporarily occluded by a tape loop.

As pulsation in the sac was absent following this proximal and distal occlusion, and the structures were firmly adherent to each other, the sac wall was opened and profuse bleeding and sucking of air occurred from a large hole in the axillary vein opening into the sac of the varicose aneurysm. This aperture allowed the aspiration of air, so the area was flooded with saline and a pack inserted. This controlled both the aspiration of air and the hæmorrhage.

It was now necessary to secure and ligate the axillary vein above and below the opening into it. There was so much fibrosis that dissection was hazardous and the vein was torn. Bleeding was severe and so the clavicle was rapidly disarticulated at the sternoclavicular joint and its inner portion removed. Dissection of the subclavian vein was begun in the scar tissue around the

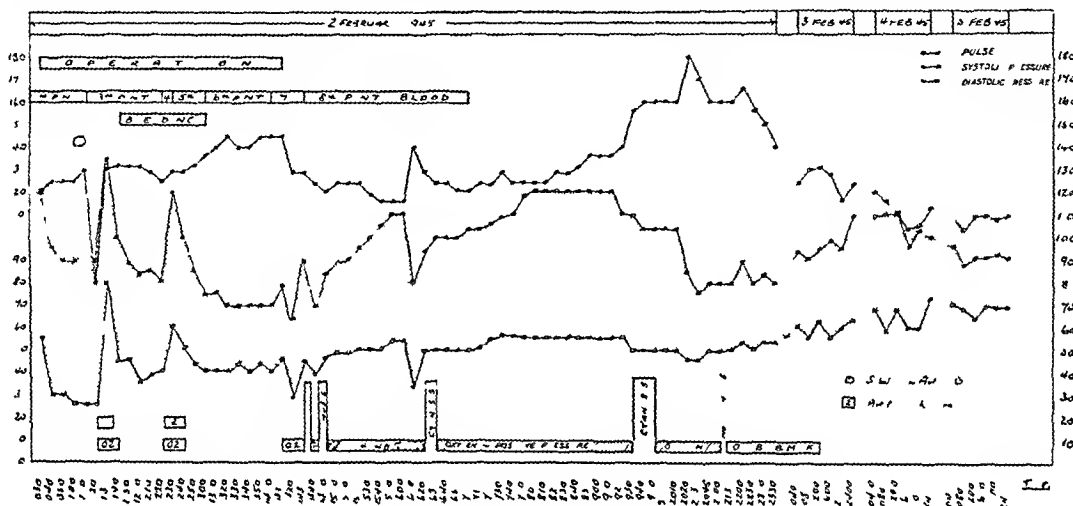


FIG 338—Operation chart

the scapula was explored. Clot was gently removed and the wound found to lead through the quadrilateral space to a traumatic arterial hæmatoma of the axillary artery. A pack was inserted to control the hæmorrhage and blood transfusion was begun. As the pack controlled the hæmorrhage completely and did not impair the limb circulation it was decided to wait a few hours and then attempt what was bound to be a formidable operation from the front.

**OPERATION (J. J. M. B.)**—On Feb 2, with the second pint of fresh blood running, operation was carried out under pentothal and intrapharyngeal gas and oxygen (G. L. F.). An incision was made along the upper border of the medial two-thirds of the right clavicle and downwards over the clavicle into the delto-pectoral groove. Numerous dilated and distended veins were secured and the clavicular head of the sternomastoid was divided. The structures above the clavicle were matted together and dissection in the midst of a multiplicity of dilated veins was very difficult. The outer border of the scalenus anterior was identified and a large vein crossing it was divided between ligatures. The subclavian artery lay behind the clavicle and was difficult to reach, so the clavicle was divided. Retraction of the clavicle allowed the second part of the artery to be cleared and a tape loop was passed round it for temporary control of bleeding. This had no effect on the pulse or blood-pressure. Dissection was then begun below the clavicle by opening up the delto-pectoral groove. The pectoral

entry wound, but the vein was torn in the process and had to be tied at its junction with the internal jugular vein. There was still some bleeding from the proximal vein and this was found to be coming from the transverse scapular vein, which was ligated also. The axillary vein was freed distal to the fistula and ligated.

The sac was again inspected and found to be a large varicose aneurysm which was passing through the quadrilateral space, and the pack inserted from behind was identified and removed. The hole in the first part of the axillary artery was identified and the artery ligated above and below it and its division completed. There was still some bleeding from the venous opening and this was treated by occluding the opening by suture.

The wound was insufflated with penicillin-thiazole powder and three tubes were inserted for penicillin instillation. The posterior wound was also closed over penicillin tubes.

Condition at the end of operation which lasted 2 hr 40 min was very poor. Transfusion of fresh blood was continued throughout the operation, the transfusion being maintained at a speed as far as possible equal to the blood-loss. Circulation in the right arm was poor, but seemed no worse than that in the other limbs.

**The Effects of Oxygen**—Operation concluded 14.10 hr. At 14.30 hr, as soon as oxygen under positive pressure was stopped, cyanosis was evident and the blood-pressure fell from 90/45 to 70/40. Similarly, when oxygen was stopped at 14.50 hr there was immediate cyanosis and

oxygen was continued until 16.20 hr, when its cessation was again followed by cyanosis. Oxygen was therefore continued under positive pressure for another three hours and once again its cessation was followed by a gradually deepening cyanosis with a remarkable deterioration in general condition with rising pulse and a remarkable fall in pulse pressure (*Fig 338*). Seven hours after operation positive pressure oxygen was stopped and there was no cyanosis so the patient was returned to bed, oxygen being continued by B.L.B. mask until 12.00 hr the following day.

**PROGRESS**—Blood-pressure and pulse became stabilized at 110/70 and 90 respectively three days after operation, and the patient made a reasonably rapid recovery.

The circulation of the right arm was never in doubt and there was no oedema following the venous ligation.

Intramuscular penicillin 15,000 units three-hourly up to 1,000,000 units was given and local instillation was continued for five days. There was no further hæmorrhage and there was only superficial breaking down of the wound. A small sequestrum was extruded from the lateral end of the clavicle on March 14, when the wound was clean with flat granulations and ready for grafting.

On Feb. 5, i.e., three days after operation, R.B.C. 3,600,000 Hb, 88 per cent S = 75 per cent H, and colour index 1 approximately.

The peripheral nerve lesion was unchanged following operation and there were no superadded ischæmic changes. The loss of the clavicle did not seem to be much of a handicap.

On Feb. 24 there was no sign of union in the jaw, which was resplinted by Major Battle, and on March 17 the patient was transferred able to walk to Maxillo-facial Unit under the care of Major Battle. There was no murmur over the wound and no sign of blood-vessel lesion.

### COMMENT

This case brings out certain points in the treatment of leaking aneurysm—

1 It emphasizes the difficulties of operation during the fourth week after injury in the presence of wound sepsis and fibrosis.

2 It is essential to have transfusion with fresh blood available and to counterbalance blood-loss with blood replacement. The transfusion must be in the hands of a skilled resuscitation officer working in close co-operation with the anaesthetist.

3 A running record of pulse and blood-pressure must be maintained and readings are taken every five minutes at operation and quarter-hourly on return to bed. (To save space the chart, *Fig 338*, only illustrates ten-minute intervals until return to bed and then four-hourly readings on the three immediate post-operative days.) It is only in this way that the resuscitation officer is able to regulate the transfusion accurately.

4 The dangers of secondary hæmorrhage following operation have been greatly lessened by penicillin.

5 No matter how apparently hopeless the outlook at operation may be, every effort should be made to complete the control of hæmorrhage and to treat the hæmorrhage and shock.

6 The amount of blood replacement was reasonably accurate, but it was not until twenty-two hours after operation that oxygen could be dispensed with, and control of the peripheral vasomotor mechanism was not re-established until the third post-operative day.

7 Operation must aim at controlling the proximal and distal artery and vein before approaching the site of the lesion. Because of fibrosis the proximal vein was difficult to isolate and was the cause of the trouble at operation.

It is no exaggeration to say that this case proves the old adage that while there is life there is hope. The credit for the successful outcome must be given in no small measure to the nursing skill and enthusiastic devotion of Sisters S.E. Wyvill and M. Thomas, to whom our grateful thanks are due.

We are indebted to Colonel L. J. Haydon, O.C. Hospital, for his permission to quote from the hospital records.

## FULMINATING GAS GANGRENE INFECTION FOLLOWING AN ISCHIORECTAL ABSCESS

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FULMINATING gas gangrene infection following upon an ischiorectal or perirectal abscess is a rare condition, and few cases have been described.

The only strictly comparable case to the present one is that described by Berkow and Tolk (1923), which ended fatally, while the case described by Campbell (1929) seemed to be a much milder infection.

### CASE REPORT

**HISTORY**—The patient, E.C., a married woman aged 59, was admitted to the Cardiff Royal Infirmary on Sept. 19, 1944, at 8.0 p.m. Two days prior to admission the patient noticed a small swelling in the

right buttock. This was not painful at first, but later it became tense and throbbing.

On the day before admission the right side of the vulva became swollen and the skin of the buttock and the right labium showed a brownish discoloration. The patient felt very tired and weak, and her appetite was poor.

On the day of admission the discoloration of the skin had become deeper in hue and had extended up the right labium on to the anterior abdominal wall. The patient felt fatigued and weaker and her general condition had gradually deteriorated. She had noticed that her urine was much darker than usual.

**ON EXAMINATION**—The patient's general condition was poor, she looked toxic, and was obviously profoundly

ill She had a dry furred tongue, a pulse of 140, of fairly good volume, and a temperature of 99°

Locally there was a right-sided ischio-rectal abscess 3 in in diameter, which was fluctuant and tender. There was a marked dark-brown discoloration of the right buttock, the medial aspect of the right thigh, the right labium, and the anterior abdominal wall within 2 in of the umbilicus (Fig 339). The condition of the anterior abdominal wall resembled in its distribution the appearance sometimes seen with superficial extravasation



FIG 339—Colour photograph showing a right-sided ischio-rectal abscess, with the typical discoloration of the skin, extending along the right labium and medial aspect of the right thigh

of urine. An interesting fact was that the discoloration also extended up the right side of the vagina.

Creptitations could easily be felt and heard in the discoloured areas, especially in the right labium and in the right iliac fossa. The discoloured area had a fairly well-marked, raised edge and the whole area was painful and tender to touch. Rectal examination elicited marked tenderness on the right side overlying the abscess. On catheterization of the bladder 6 oz of foul-smelling, dark urine were removed. It contained a trace of sugar, but no blood or ketones.

**TREATMENT**—A pre-operative injection of morphine (gr  $\frac{1}{2}$ ) and atropine (gr  $\frac{1}{100}$ ) was given, and under general anaesthesia the ischio-rectal abscess was opened by a cruciate incision. On opening the abscess the characteristic musty odour of the gas and blood-stained fluid was well marked. The necrotic tissue in the abscess cavity was black in colour, and this debris was evacuated. On exploration of the abscess cavity it was found that it extended up the right labium to the pubic region (Figs 340, 341).

The cavity was packed with approximately 15 g of sulphathiazole-proflavine powder (sulphathiazole 99 parts, proflavine 1 part) and vaseline gauze.

On return to the ward the patient's pulse was 120 per minute and of fair volume. Sulphadiazine tablets, 6 immediately and 3 four-hourly, were prescribed and 50,000 units of polyvalent antitoxin were given intravenously and repeated six-hourly. An intravenous glucose drip was set up. During the night her condition did not change appreciably. In the morning she was conscious and rational, but markedly apathetic. The area of discoloration was spreading and becoming much darker. Her temperature was now 97.5°, pulse 120 and of fair volume.

At 10 p.m. on Sept 20 penicillin therapy was begun by the intramuscular route with the injection of 30,000 units, 15,000 units were then given three-hourly for four injections, making a total of 90,000 units.

The patient's general condition, however, gradually became worse and during the day she vomited several

times. At 8.0 p.m. she became slightly irrational, the pulse was of poor volume with a rate of 150 per minute, and the temperature was 97.5°, 2 c.c. of anacardone (nikethamide) were now given by injection. Three hours later the pulse-rate was 180 per minute and hardly perceptible, and the temperature was 97.5°. The patient



FIG 340—Colour photograph showing the black necrotic debris after opening the abscess



FIG 341—Colour photograph showing the extent of spread of the infection along the superficial tissue planes on to the anterior abdominal wall, resembling the picture sometimes seen with superficial extravasation of urine. The abscess cavity has been packed with sulphathiazole-proflavine powder

became very irrational, her general condition rapidly deteriorated and she died at 2.30 a.m. on Sept 21, thirty hours after admission.

Quantitatively, therapy had consisted of—

- a 15 g of sulphathiazole-proflavine powder locally
- b 200,000 units of polyvalent antitoxin intravenously
- c 90,000 units of penicillin intramuscularly
- d 24 g of sulphadiazine orally
- e 2400 c.c. (approx) of 5 per cent glucose solution intravenously

**POST-MORTEM EXAMINATION** (P. M. 192/44)—Performed by Dr J. Gough, on Sept 21.

The body was that of a well-nourished middle-aged female. Externally there was a purplish discoloration of the skin of the right lower half of the abdomen and right flank, and upper part of the right thigh. There was no evidence of any other disease or injury.

There was an abscess in the right ischio-rectal region. The whole region was black and gangrenous. The gangrene had extended along the right labium on to the abdominal wall in the subcutaneous tissues, in which

there was blackening of the tissues, which contained foul black fluid and gas

*Internally* The pharynx, œsophagus, stomach, and small intestine were normal. The rectum contained hæmorrhoids, but they were not inflamed. There was also one small uninfected anal fissure, but no fistula could be demonstrated between the ischio-rectal abscess and the rectum.

The liver (1400 g) was pale, but there was no gas formation in its substance. The cortex of the right kidney (150 g) was pale. The surface was finely granular, and the capsule was somewhat adherent. The left kidney (150 g) was similar to the right.

The heart (270 g) was normal except for slight coronary atheroma. All other organs were normal.

**BACTERIOLOGICAL REPORT** (Dr H L Carruthers) — Sept 20 (24 hours before death) — Specimen, *Blood-clot* —

*Macroscopical examination of cooled-meat culture* Numerous Gram-positive cocci and bacilli with small numbers of bacilli having the morphology of *Cl welchii* present.

The *Cl welchii* was not grown on blood-agar anaerobically, but this, in my opinion, was a matter of a technical fault only.

Sept 21 Specimen, *Swab* from P M 192/44 — *Direct examination of swab* Gram-positive cocci, bacilli, and numerous bacilli resembling *Cl welchii*.

*Aerobic culture* *Staph aureus*, *Staph fecalis* in small numbers, with a good growth of a non-hæmolytic streptococcus.

No further anaerobic culture was made in view of the presence of *Cl welchii* in the first specimen.

### COMMENTARY

The case described is an example of the acute fulminating type of gas gangrene infection, following upon an ischio-rectal abscess. The literature shows that such an association of conditions is comparatively rare, and only two similar cases could be found.

The first case was described by Berkow and Tolk in 1923. Their patient, a man aged 54 years, was admitted to hospital complaining of pain and swelling in the region of the anus and scrotum of six days' duration. There was nothing of note in his previous history.

There was a large, red, indurated area in the ischio-rectal region, extending to the left buttock, and a provisional diagnosis of ischio-rectal and peri-urethral abscess was made. The day following admission, using ethyl chloride locally, multiple incisions and drainage of the ischio-rectal region and scrotum were performed. The scrotum was enormously swollen and bluish in parts, when incised, dark blood, gas bubbles, and foul odour were noted. Later the incisions were flushed with hydrogen peroxide. Four hours after the operation skin crepitation was present just above the pubis, and the skin was becoming red and very tender. Five hours later the skin was indurated and crepitant.

Next morning the patient complained of great pain in the lower abdomen, and crepitation and induration were present to about 4 in above the symphysis pubis. On the following day the patient was irrational, the crepitation increased, pulmonary œdema developed, and death occurred 79 hours after admission.

The temperature on admission was 99° F. 36 hours later it rose to 101.2° F and then fell to 98° F.

The pulse varied from 100–128 per minute. Smears showed a profusion of short rather thick Gram-positive bacilli, and subcultures produced gas, but there was no further differentiation as to type.

Post-mortem examination revealed marked local and general changes, but no fistula was found between the ischio-rectal abscess and the rectum.

Their case, however, did not receive any anti-toxin.

The only other case of gas gangrene infection of this region that Berkow and Tolk could find in the literature was that described in 1919 by Thibault and Schulmann of gangrene of the scrotum from anaerobic infection, but later in 1929 Campbell described a case of "perirectal abscess due to gas bacillus."

His patient was a woman aged 34 years, who gave a two-day history and had an immense boggy swelling posterior to the anus and extending entirely across the buttocks with a gangrenous spot about three inches to the right of the anus. On the way to hospital the gangrenous spot ruptured, emitting a large amount of foul smelling pus and gas bubbles. The abscess area was crepitant, and the 48-hour culture grew the *B welchii*.

Using ethyl chloride locally the abscess was then laid wide open, and three days after admission, as soon as it could be obtained, 40 c c of *perfringens* antitoxin was administered intravenously. The patient's condition changed dramatically, and eleven days after admission she left hospital, with an anal fistula, which was excised two months later, followed by complete recovery.

The route of infection in such cases as these is of interest, and Greeley (1918), writing on "Idiopathic *Bacillus aerogenes capsulatus* Infection", notes that "as the organism is a recognized common inhabitant of the intestinal tract and of distinct pathogenic abilities, it would be expected that lesions of the abdominal organs would not infrequently be followed by inflammation directly caused by this bacillus."

In view of these facts, Berkow and Tolk assumed that the route of the ischio-rectal infection was through the gastro-intestinal tract, by way of a fistula communicating with the ischio-rectal region. But in their case, and in the one now reported, a macroscopic fistula could not be demonstrated.

The seriousness of gas gangrene of the buttock has been stressed recently. Macfarlane (1943) pointed out that "patients in whom the gas gangrene involved the thigh or buttock region showed a poorer response to treatment than those in whom the lower leg or arm was affected. This was thought to be due to the difficulty of controlling the infection in a region with a relatively poor collateral circulation and in which surgical elimination of the infection might be difficult or impossible."

MacLennan (1944), writing on "Anaerobic Infections in Tripolitania", stated that "gas gangrene of the buttock is especially dangerous", and reported 2 cases, both ending fatally.

Macfarlane (1945), in a later communication, when dealing with cases of gas gangrene of the buttock, thigh, and shoulder, noted that "the death-rate in this type of case was absolutely much higher than in the cases with gas gangrene of the

leg or arm", and that "in spite of the best treatment which could be given in these circumstances the death-rate from gas gangrene in these sites remains about 45 per cent."

Such a severe case as the one described, with marked toxæmia, calls for intensive treatment, and all available methods of therapy must be employed.

MacLennan notes that accurate diagnosis is most important. In the present case, however, diagnosis was easy, therapy was the main problem.

Most authorities agree upon the urgency of appropriate surgical treatment, but as has been pointed out previously, this is more satisfactory in gas gangrene of the limbs than in infection of the trunk, especially of the buttock region. The most that can be done in the buttock region is to open up the infected area adequately, perform as thorough a surgical toilet as possible, and then apply an efficient wound antiseptic. For this purpose McIntosh and Selbie (1944) suggested a powder consisting of 1 part proflavine and 99 parts sulphathiazole, and in the present case 15 g of this powder were introduced into the abscess cavity.

They also reported favourable experimental results (1943, 1942) with sulphadiazine, followed later by Hac and her associates (1943), 26 g of this drug were given orally.

One of the most important features of the present case was the marked toxæmia, even after intensive therapy. Florey and Cairns (1943) observed that even when good surgery was combined with the use of so efficient a bacteriostatic agent as penicillin and the spread of infection had been arrested, the patient might still die of toxæmia.

A recent leader in *The Lancet* (1944) pointed out that "even when excision has removed the main source of the infection, toxin production may continue in small inaccessible remnants of necrotic tissue. It is the toxæmia that kills, antitoxin in adequate amounts is essential."

The use of antitoxin in prevention and treatment of gas gangrene has been fully stated, and in the case now reported doses of 50,000 units 6-hourly were prescribed, with a total of 200,000 units.

Many have written on the use of penicillin in gas gangrene infections, including Jeffrey and Thomson (1944), who were convinced of its value in checking the spread of the infection, although clinical improvement was not obvious until 36 hours after commencement of penicillin therapy. This is of importance in the present case when it is considered that the patient died 13½ hours after penicillin therapy was begun.

Despite all this intensive treatment the patient died 30½ hours after admission to hospital with only a two-day history. This case admirably illustrates the truism, "it is the toxæmia that kills."

My thanks are due to Mr J Berry Haycraft for allowing me to treat the case and to publish this account, to Dr Jethro Gough for the post-mortem notes, to Dr H L Carruthers for the bacteriological report, and to Dr L P Thomas for the colour photographs.

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## VOLVULUS OF THE CÆCUM REPORT OF A CASE

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VOLVULUS of the cæcum was first described by Rokitsky in 1841. The condition is considered to be rare, Miller (1940) finding only 1 case out of 136 cases of acute intestinal obstruction in the Mayo Clinic, and Rothman et al (1943) noting 1 case out of 150 cases of obstruction at the Harlem Hospital. The condition appears to be commoner outside the English-speaking countries, and certain European writers, especially Du Roux (1912) and Gatellier et al (1931), have pointed out that the lesion is found oftener in Russia, Poland, Finland, and Scandinavia. Wolfer et al (1942) believe that more than 300 cases had been recorded up till the time of their publication.

The condition appears to depend for its causation primarily upon excessive mobility of the ascending colon and terminal ileum, and thus to a failure in the fusing of mesenteries in the third stage of intestinal rotation. It is interesting to note that although, as Bryant (1921) pointed out, this latter anomaly is much commoner in the female, volvulus of the cæcum is three times commoner in the male subject.

Many different exciting causes have been given, such as over-exertion, violent peristalsis from over-eating or heavy purgation, and pregnancy. A few cases appear to have been associated with pregnancy, and Drayer (1911) described the mechanism by which the pregnant uterus displaced and twisted the mobile cæcum.



There are varying degrees of the process depending upon the mobility of the right colon and grading from the condition where there is a common ilocolic mesentery so that the colon may turn upon the superior mesenteric vessels as an axis, to the one where the isolated cæcum may turn upon itself in its cul-de-sac so that obstruction of the bowel is not caused. In the average case the cæcum with a few inches of the lowest ileum and the proximal ascending colon are the parts involved.

In most of the cases described the rotation of the bowel has been in a clockwise direction. This is not surprising as it is obviously much easier for the mobile ascending colon with its medial mesentery to roll in a clockwise direction towards the centre of the abdomen than to attempt to roll laterally beneath its own mesentery. Rothman et al (1943) point out that the degree of torsion must be at least 180° upon its mesenteric border, as pathological changes do not occur before then.

The treatment of the lesion must be prompt because of the rapid distension of the cæcum and the imminent danger of rupture of its thin wall. The mortality of the recorded cases is over 50 per cent. In Valentine and Kinnear's case (1937) death occurred within five hours of the onset.

### CASE REPORT

**HISTORY**—M. B., aged 42, a bricklayer, was admitted to hospital with a history of acute abdominal pain and vomiting of eight hours' duration. The pain had come on at 3 a.m. while the patient was asleep in bed and had awakened him suddenly with its intensity. It was



FIG. 342.—Photograph taken at operation showing the marked dilatation of the cæcum and adjacent ascending colon.

first felt in the upper abdomen, but after an hour or two had tended to settle in the right iliac fossa. Three hours after the onset vomiting commenced and continued to occur every half hour or so until admission, dark-green material being brought up on each occasion. The pain slowly increased in intensity and was constantly present, although the patient admitted that there were exacerbations of a more acute stabbing pain. Nine months previously he had had a similar attack of pain, but on that occasion it had been much less severe and had disappeared spontaneously after two hours.

**ON EXAMINATION**—Physical examination disclosed a rather unhealthy, sallow male subject. The abdomen

showed a slight generalized distension. In the right iliac fossa there was a prominent bulge which was exquisitely tender and tympanitic on percussion. The pulse on admission was 84 per minute and the temperature 98.4° F. The bowel moved soon after admission, the stool being fairly scanty but normal in appearance. The condition was diagnosed as volvulus of the cæcum and operation carried out half an hour after admission.

**AT OPERATION**—The abdomen was opened by a right paramedial incision under ether anaesthesia. The distended cæcum at once bulged from the wound and there appeared to be a marked danger of its rupturing. The wound was enlarged and the distended loop delivered (Fig. 342). The cæcum with the lowest ileum and adjacent ascending colon had undergone torsion in a clockwise direction and had rotated through 540°, i.e., one-and-a-half circumferences. It was gently untwisted and some of the gas forced into the ascending and transverse colon. The appendix was then removed and the purse-string sutured to the peritoneum at the lower end of the wound to prevent any recurrence of the condition. The abdomen was then closed in layers without drainage.

**PROGRESS**—Apart from a slight tendency to post-operative distension for a few days, the patient made an uninterrupted recovery, the temperature remaining normal and the pulse never rising above 84. He has remained well since the operation, now six months ago.

### COMMENT

Examination at the time of operation showed that the cæcum and lower ascending colon were very mobile, but that the colon became abruptly firmly fixed to the posterior abdominal wall at a point slightly above the middle of the ascending colon, and it was at this point that the torsion had occurred. General hyperfixation of the colon wall, of course, preclude any possibility of cæcal volvulus, but, as Carslaw (1928) pointed out, hyperfixation is often localized and is found particularly in the right colon. It will be appreciated that a point of hyperfixation in the ascending colon associated with looseness of the proximal part, such as was present in our case, provides a perfect combination conducing to volvulus, the mobile cæcum rotating round the fixed point, which acts as a hub. There was no apparent exciting cause present in our case.

The history of a similar attack of pain which subsided spontaneously is interesting and might be accepted as an argument for some form of fixation operation in those cases of mobile cæcum which form such a large proportion of the "chronic appendicitis" clinic.

In the treatment of the condition it seemed to us sufficient to attach the cæcum to the anterior abdominal wall at the operation wound.

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## CHYLOTHORAX FOLLOWING TRAUMATIC PSEUDOCYST OF THE PANCREAS

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### CASE REPORT

An able seaman, aged 23, was in hospital from May 3, 1944, till Feb 26, 1945, following a kick in the epigastrium. During that time he developed a pancreatic cyst, bile peritonitis, chylothorax, and chylous ascites.

The sequence of events was as follows—

**May 3, 1944** Admitted to Astley Ainslie Institution about two weeks after injury. He was kicked in the epigastrium at football, and continued to play for a few minutes, but then collapsed. He was in bed for a week and then sent on leave, still with persistent pain in the back. The day before admission he also had pain in the centre of the abdomen and right shoulder, with anorexia but no nausea or vomiting. He stated that his urine had been dark since the accident, and his bowels regular.

He was a pale slight man, not acutely ill. T 97.4°, P 80, R 20. Beyond some tenderness in the epigastrium and right hypochondrium, no abnormality was found. The urine was normal.

**May 12** Severe pain in the back and nausea. Very tender in epigastrium and right renal angle posteriorly. The stomach was dilated with wind, which was relieved with aq. menth. pip.

**May 15** A second attack as above, with also abdominal distension. This was relieved partly by a flatus enema and partly by gastric aspiration. The icteric index was 6.

**May 25** A third attack. Gross gastric dilatation, the percussion note being tympanitic nearly up to the left axilla and the apex beat displaced to the right. Continuous gastric suction brought some relief, but the abdomen remained distended, this time with fluid.

**May 31** 22 oz of fluid withdrawn from the abdomen. It was sterile and contained blood and bile.

**June 2** 136 oz fluid withdrawn in eighteen hours.

The abdomen was tapped another four times at weekly intervals, 6 oz, 84 oz, 40 oz, and 50 oz of fluid being withdrawn. It contained bile in diminishing amounts and was always sterile. The patient was very miserable, was losing weight, and would not eat. He slept badly and complained of pain in the right hypochondrium.

**June 27** FIRST OPERATION (Brigadier Anderson). Much turbid fluid was found in the abdomen. The bowel was distended and covered with fibrin flakes. No liver or gall-bladder injury was seen. The lesser sac was occupied by a pseudocyst of the pancreas, which was drained. The peritoneum was drained through a suprapubic stab wound.

After operation the patient was very ill. Plasma and later saline were given intravenously, and continuous gastric suction applied. After two days these were stopped. Both tubes drained profusely. The suprapubic drain was removed after four days. The drainage from the pancreatic cyst began to macerate the skin, so continuous suction was applied to the tube. Upwards of a pint was removed daily for a week. The diastatic index of this fluid was over 500 units/c.c.

**July 11** Tube removed. Some discharge continued for two weeks, and the wound was healed by the middle of August. The patient was now better, but very thin. His appetite was poor and he slept badly. He was apathetic and still had pain in the right hypochondrium

and shoulder. A barium series was normal. Cholecystography showed no gall-bladder shadow.

**Aug 27** Left-sided pleural effusion discovered.

**Aug 30** One pint of milky fluid aspirated from chest. It was sterile and contained chyle. Aspiration was repeated seven times at about 10-day intervals, from 6 oz to a pint was removed at a time. Chyle was always present in diminishing amounts, and it was sterile.

In the middle of September he was less well, with an evening temperature up to 100° F, and he still had pain in the right hypochondrium. The laparotomy scar broke down and discharged pus for three weeks.

**Sept 30** Gas found below the diaphragm by radiography.

**Oct 3** SECOND OPERATION (Brigadier Anderson). Resection of end of 12th rib. No pus found, but granulation tissue in the subphrenic space. A large rubber tube was sutured into the wound.

**Oct 5** Profuse sero-purulent discharge from the tube. Culture—scanty *Staph aureus* and *Str hæmolyticus*.

The tube was removed after nineteen days, after which the wound healed slowly. For three days he had diarrhoea and tenesmus, with tenderness in the pouch of Douglas. This subsided without treatment.

**Oct 17** Abdominal distension noted.

**Oct 23** 1½ pints of sterile chylous fluid withdrawn by abdominal paracentesis. General condition poor, very pale and thin. Hb 67 per cent. Serum proteins 3.5 per cent.

**Oct 25** Blood transfusion—one pint of fresh blood, followed by two-thirds of a pint of reconstituted dried plasma, stopped because of a slight rigor. High protein diet ordered and amino-acid digest by mouth.

**Oct 26** Profuse discharge of thick bile from anterior abdominal wound. The discharge required four changes of dressing in the day and ceased abruptly after two days. The wound healed and remained so except for a superficial abscess, which was opened on Nov 22 and healed in a week. The general condition now began to improve, he ate enormously and put on weight, and became cheerful and interested. The abdomen was tapped a further four times up to Dec 1, after which it ceased to fill up. From 2 to 4 pints of fluid were withdrawn on each occasion—milky-white fluid, containing chyle and always sterile. The fat content was 1.44 per cent and protein 1.5 per cent. Cells scanty, no admixture of pancreatic fluid. He developed a small right-sided pleural effusion which was tapped once, clear, sterile, serous fluid being withdrawn.

**Jan 28, 1945** Developed a bad cold in the head, with frontal sinusitis and small patch of consolidation at base of right lung. He made a good recovery with sulphadiazine (26 g in 5 days). Other treatment given was a course of exercises and massage for the feet and legs, and ultra-violet light.

By the end of February he was up for most of the day, looking healthy, and with no abnormal physical signs apart from some pleural thickening at the right base, and muscle weakness consequent upon his long stay in bed.

**Feb 26** Discharged to naval hospital for convalescence and final disposal.

Other investigations that were carried out showed no abnormality of the urine at any time, apart from a

trace of albumin the day after his blood transfusion, and no increase in the fat content of the stool

### DISCUSSION

The original injury sustained as a result of the kick seems to have been to the pancreas, leading to effusion of pancreatic fluid into the lesser sac and formation of a pseudocyst. This pseudocyst gradually increased in size, and was probably partly responsible for the large peritoneal effusion by pressure on the inferior vena cava. In addition, there must have been some injury to the biliary apparatus, though this was not obvious at operation, to account for the considerable quantities of bile found in the fluid. This bile caused an aseptic peritonitis, which increased the effusion and accounted for the obvious inflammation found at operation. On account of the inflammation and fibrinous exudate it was not possible to see the bile-ducts, but it is thought that there must have been a small tear either at the neck of the gall-bladder or in the cystic duct. This is borne out by the fact that (a) There was no jaundice, therefore no obstruction of the common bile-duct, (b) The stools always contained

bile-pigments, and (c) A cholecystogram showed a non-functioning gall-bladder. The biliary fistula which developed six months later was probably the escape of a collection of bile which had been localized in that area by adhesions resulting from the operation and the presence of a drainage tube. What is more difficult to account for is the chylothorax and subsequent chylous ascites. There was no chyle in the peritoneal effusion in the first series of tapplings, therefore the escape of chyle was a late development and not part of the original injury. Why it should have appeared first in the left pleural cavity and afterwards in the peritoneum is a mystery. Draining the peritoneum had no effect on the pleural effusion.

The mortality of a traumatic (as distinct from a malignant) chylothorax is given as 75 per cent, and it is a wonder to all who saw this patient at his very ill stage that he made such a remarkable recovery.

I wish to thank Brigadier Anderson and Lieut-Col Cunningham, Medical Superintendent of the Astley Ainslie Institution, for permission and encouragement to publish this case.

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## REVIEWS AND NOTICES OF BOOKS

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### Proceedings of the Congress of CMF Army Surgeons, Rome, February, 1945

THE campaign in Italy, partly because of accidents of time and circumstance, but largely because of the ability and energy of the men who formed the medical services and the men who directed them, has been the most fruitful university for the study and advancement of military surgery in the history of the war. In Italy the surgeons from Middle East, First Army, and the American Forces first met. In Italy the lessons of a mobile desert campaign and of more static warfare among the mountain passes of Algeria were blended and subjected to the scrutiny of a band of enthusiasts fresh from civil surgery and centres of research. In Italy penicillin was first tried on a useful scale, and two-stage wound closure was developed as a planned policy. Here, too, the medical services were for the first time well supplied and well protected, and were able to evolve the methods that later proved their soundness in the final campaign in north-west Europe. This experience was discussed freely and frankly at a five-day conference held in Rome in February, 1945. The papers which were read at that congress, and the discussions which followed them, in which many visitors from other theatres of war took part, are reported in this volume.

The papers on the first day were devoted almost entirely to the treatment of wounds of the limbs, with special emphasis on the factors which had been found important in the primary and secondary operations of two-stage closure, and in the closure of compound fractures. Each speaker discussed some aspect of the problem on which he was particularly qualified to give an opinion, and the papers as a whole form a comprehensive account of this most important aspect of war surgery. The last contribution in the afternoon session, by Captain G. Parish, summarized the results of wound closure after the Gothic line battle, in 2693 cases operated upon there were only 9 per cent failures among compound fractures and 6 per cent among flesh wounds.

On the morning of the second day the delegates to the congress were received in audience by his Holiness the Pope. At the afternoon session, devoted to thoracic surgery, papers were read by Lt-Col d'Abreu, Major Nicholson, Captain Hodgkins, NZMC, and Major Maxwell Telling. These papers are among the most valuable in the proceedings, recording as they do the transition from the conservative attitude of the first world war and the earlier stages of this one, to the more radical outlook of to-day.

The subject of abdominal trauma was discussed on the third morning, and in the afternoon a clinical meeting was held at No. 10 Convalescent Depot. The marked improvement in the results of the surgery of abdominal wounds that is obvious in all published figures is due in the main to accessory methods such as transfusion, gastric suction, and venoelisis. One new principle, that of the exteriorization of colon wounds, has appeared, and Major Estcourt, reviewing the treatment of wounds of the large intestine, endorses this policy, but makes the plea that small wounds, particularly those of the right colon, should be treated by suture and drainage. In summing up Brigadier Edwards voiced the opinion of most experienced consultants in pleading that the policy of exteriorization should not be lightly discarded.

The papers on the fourth and fifth days are too important, and cover too wide a range of subjects, for any brief summarization. Injuries of the urethra, vascular injuries, burns, protein metabolism, resuscitation, cranial and facio-maxillary surgery, were all dealt with. Mention may be made of two papers on protein metabolism by American surgeons, Captain Somers H. Sturgis and Lt-Col Harwell Wilson, followed by one on the same subject by Major R. S. Garden, R.A.M.C. The three papers form an excellent summary of present knowledge on this very important subject, and are followed by a short but useful list of references. A short paper by Major P. Clarkson and T. H. H. Wilson and Captain R. S. Lawrie on the treatment of 100 jaw wounds

summarizes an experience in this particular aspect of war surgery that is probably unique

This publication, which appears to be the work of the British Military Printing Press, is excellently and clearly produced on good paper and illustrated by six charts, one of them in six colours. It is probably the most valuable contribution on war surgery that has ever appeared. To future students of the surgery of the world conflict that has just ended it will form a more fruitful source of information than any official history is ever likely to be.

**The Medical Annual, 1945** A Year Book of Treatment and Practitioner's Index (Sixty-third Year) Edited by Sir HENRY TIDY, KBE, MA, MD (Oxon), FRCP, and A RENDLE SHORT, MD, BSc, BSc, FRCS  $8\frac{1}{2} \times 5\frac{1}{2}$  in Pp 410 + ix, with 47 plates and 61 illustrations in text 1945 Bristol John Wright & Sons Ltd 25s net

A REPATRIATED medical officer who had been a prisoner of war in Japan for nearly four years asked where he could find concise yet reliable information on some of the war-time advances in medicine and surgery, he mentioned penicillin and thiouracil as examples. What better volume than *The Medical Annual* could one recommend? Here he will find an excellent account of both, as well as summaries of the world's literature on other recent developments. They are not too short nor too long, and are authoritative and well documented for those who wish for more detailed information on any subject. The production and illustrations are excellent.

**Duodenal and Jejunal Peptic Ulcer** By RUDOLF NISSEN, MD, Attending Surgeon, Jewish Hospital of Brooklyn, formerly Professor of Surgery and Head of Department of Surgery, University of Istanbul, and Associate Professor of Surgery, University of Berlin. With a Foreword by Professor OWEN H WANGENSTEEN  $8\frac{1}{2} \times 5\frac{1}{2}$  in Pp 143, with 123 illustrations 1945 William Heinemann (Medical Books) Ltd 21s net

THIS book is devoted to the procedures and recent advances in the surgery of peptic ulcer. It is well illustrated and contains some useful, practical points regarding technique.

**The Treatment of Peptic Ulcer** Based upon Ten Years' Experience at the New York Hospital. By GEORGE J HEUER, MD, Professor of Surgery of Cornell University Medical College, Surgeon-in-Chief of the New York Hospital, assisted by CRANSTON HOLMAN, MD, and WILLIAM A COOPER, MD, Assistant Professors of Clinical Surgery, Cornell University Medical College  $9 \times 5\frac{1}{2}$  in Pp 118 + xii 1945 Philadelphia and London J B Lippincott Co 18s

THIS small monograph of just over a hundred pages presents a detailed study of some 1139 case histories of patients suffering from peptic ulcer. It consists of a 10-year clinical study in which 98.2 per cent of the patients were followed up and the various forms of treatment assessed.

This comprehensive survey of such a large number of cases is interesting and uncommon, and every surgeon who is interested in gastric surgery should study this monograph.

It is interesting to read that the authors do not find that extensive gastric resections produce better results

than smaller resections, although the reduction in acid is greater.

In estimating the results of gastro-enterostomy and gastric resection, it has repeatedly been claimed that the great virtue of resection is that it protects the patient against recurrent ulceration and, therefore, against marginal ulcer, hæmorrhage, and perforation. The authors agree with this experience, but consider that this protection is relative and not absolute.

This monograph will form a useful book of reference.

### Bone-grafting in the Treatment of Fractures

By J R ARMSTRONG, MD, MCh, FRCS, A/W/Comm RA FMS, and Surgeon-in-Charge of an RAF Orthopædic and Fracture Centre, Registrar to the Orthopædic Department and to the Fracture Clinic, Charing Cross Hospital, London, Registrar to the Metropolitan Hospital, London. With a Foreword by R WATSON-JONES, BSc, MCh Orth, FRCS, Civilian Consultant in Orthopædic Surgery of the RAF  $9\frac{3}{8} \times 6\frac{1}{2}$  in Pp 175 + xii, with 204 illustrations 1944 Edinburgh E & S Livingstone Ltd 25s net

THIS book gives a thorough and detailed account of the technique of onlay grafting. The modifications necessary for each bone and the surgical approaches to it are carefully described. The treatment of the subject is severely practical—perhaps too exclusively so. In a book of this size it might have been an advantage to deal at greater length with the development of bone-grafting, and the discussion of the principles on which the practice depends might well have been expanded. In his concentration on the onlay graft the author is somewhat unjust in his estimation of other methods. For instance, he condemns out of hand the sliding inlay graft for the tibia in spite of the fact that it has the advantage of making unnecessary the borrowing of bone from the sound limb and that it is successfully employed by many surgeons. Further, for internal fixation in a recent fracture of the radius, he prefers to borrow bone from the tibia to using equally satisfactory and more readily available vitallium plate.

Since the book was written, the use of cancellous bone from the ilium, often in the form of chips, has been greatly extended and very good results have been obtained by this method. A second edition would no doubt be considerably modified by this experience.

The book is beautifully illustrated and produced on fine paper.

**Urological Surgery** By AUSTIN INGRAM DODSON, MD, FACS, Professor of Urology, Medical College of Virginia, etc. With contributions by seven authors  $9\frac{3}{8} \times 6\frac{1}{2}$  in Pp 768, with 576 illustrations 1945 London Henry Kimpton 50s net

THE appearance of a new work covering an extensive subject and written by one author is something of an event, and although there are seven other contributors to this volume their share is only six chapters out of a total of forty-six, the main body comes from the pen of Dr Dodson alone. His first intention was to write on Surgical Treatment, and although it was later decided to include some pathology and diagnosis the original idea pervades the book, there is little pathology but much treatment.

Some of the views are in divergence with those held on this side of the Atlantic. Radiation is claimed as the most popular method of treatment of bladder tumours, whilst carcinoma of the penis is said to be radio-resistant, the general impression here is the exact opposite. Other differences of opinion between British and American

schools of thought are also apparent, and the book is certainly more American than international, very few references other than from American literature being quoted. This is not to detract from its value as a practical guide to the surgical urologist, in it he will find detailed instructions for the performance of almost every operation in urology, including eleven methods of nephropexy!

Used as a reference book for the practising surgeon it is invaluable, it is well produced and profusely illustrated, and is a monument to the experience and industry of the author. It is also very good value for the money.

**The Principles and Practice of Rectal Surgery** By WILLIAM B. GABRIEL, M.S. (Lond.), F.R.C.S. (Eng.), Surgeon to St Mark's Hospital for Cancer, Fistula, and other Diseases of the Rectum, Surgeon to the Royal Northern Hospital. Third edition. 9½ x 6 in. Pp 432 + ix, with 11 coloured plates and 237 illustrations, some in colour. 1945. London: H.K. Lewis & Co. Ltd. 45s net.

This new edition of this well-known work will be very welcome not only among those who are interested in this branch of surgery, but with surgeons generally. The second edition was reviewed in the *BRITISH JOURNAL OF SURGERY* in 1937, and the present issue reflects the very large experience which has been enjoyed by the author during the intervening eight years and gives a very

thorough representation of contemporary rectal surgery at its best. The book has been thoroughly revised and without any great addition to its size has been improved in many ways, including the addition of several new illustrations and coloured plates. With scarcely an exception the illustrations are of a high order and the plates are successful reproductions of excellent pictures.

Two chapters have been added, one on proctitis and the other on carcinoma of the anus and anal canal. The teaching has the merit of a sound pathological background and reflects the high standard of the work which has for so long been carried out in the laboratories of St Mark's Hospital under the supervision and stimulus of Dr. Clement Dukes. The operative procedures recommended are described with great care and detail while many points which might otherwise be in doubt are elucidated by suitable diagrams. One of the valuable parts of the book is the references to the after-histories of patients, which make a storehouse of valuable information. The impact of the war has not left this field of surgery untouched, and the section on gunshot injuries is timely. In many places there is evidence of the author's wide knowledge of the literature of his subject and there is also appropriate acknowledgment of the contributions of other workers in this field. The edition continues the high standard which was set when the book was first published and will do much to sustain the reputation of rectal surgery as carried out at St Mark and as reflected in the practice of British surgery in this field.

## BOOK NOTICES

*[The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest for our readers.]*

**A Textbook of Surgery** By JOHN HOMANS, M.D., Clinical Professor of Surgery, Emeritus. Compiled from Lectures and Other Writings of Members of the Surgical Department of the Harvard Medical School. Sixth edition. 9½ x 6½ in. Pp 1278 + viii, with 530 illustrations. 1945. Springfield, Ill.: Charles C. Thomas (London: Baillière, Tindall & Cox). \$8.00.

**L'Urographie Intra-veineuse (UIV)** By BERNARD FEY and PIERRE TRUCHOT. 9½ x 6½ in. Pp 213 + viii, with 242 illustrations. 1944. Paris: Masson et Cie. 320 fr.

**The Training and Employment of Disabled Persons** A Preliminary Report. 9 x 6 in. Pp 302 + vi. 1945. Montreal: International Labour Office. 6s.

**Plaster of Paris Technique in the Treatment of Fractures and Other Injuries** By Lt-Col T. B. QUIGLEY, M.C., M.D. 9½ x 6 in. Pp 107 + xiv, with 103 illustrations. 1945. New York: The Macmillan Company. 18s net.

**Demonstrations of Operative Surgery for Nurses** By HAMILTON BAILEY, F.R.C.S., Surgeon, Royal Northern Hospital, London, etc. 8½ x 5½ in. Pp 348 + viii, with 531 illustrations, some in colour. 1945. Edinburgh: E. & S. Livingstone. 21s net.

**Le Catgut. Les Ligatures et les Sutures chirurgicales a travers les Ages** By Dr A. FANDRE. With a Preface by Professor LOUIS BRUNTZ, Nancy. 9½ x 6½ in. Pp 651 + viii, with 137 illustrations. 1944. Paris: Masson et Cie. No price stated.

**Illustrations of Regional Anatomy** By E. B. JAMIESON, M.D., Senior Demonstrator and Lecturer Emeritus, Anatomy Department, University, Edinburgh. Sixth edition. 7½ x 6 in. 320 plates. In seven sections or in one bound volume (75s net). 1945. Edinburgh: E. & S. Livingstone.

**An Introduction to Clinical Surgery** Surgical Wherefores and Therefores. A Reasoned Explanation of Surgical Note-taking. By CHARLES F. M. SAINT, C.B.E., M.D., M.S., F.R.C.S. (Eng.), F.R.A.C.S., Professor of Surgery, University of Cape Town. 8½ x 5½ in. Pp 293 + viii. 1945. Cape Town: Published for the Post-Graduate Press by The African Bookman. 25s.

**Facial Prosthesis** By ARTHUR H. BULBULIAN, M.S.D.D.S., F.A.C.D., Director, Museum of Hygiene and Medicine, The Mayo Foundation, Rochester, Minn. 9½ x 6 in. Pp 241 + viii, with 202 illustrations. 1945. London and Philadelphia: W. B. Saunders Co. Ltd. 25s net.

**A Manual of Surgical Anatomy** Prepared under the auspices of the Committee on Surgery of the Division of Medical Sciences of the National Research Council by TOM JONES, Professor of Medical and Dental Illustration and Head of Department of Illustration Studios, University of Illinois Medical School, and W. C. SHEPARD, Art Editor, W. B. Saunders Co. 10½ x 8 in. Pp 195 + vi, with 267 illustrations, 153 in colour. 1945. London and Philadelphia: W. B. Saunders Co. Ltd. 25s net.

# THE BRITISH JOURNAL OF SURGERY

VOL XXXIII

APRIL, 1946

No 132

## PAINFUL PHANTOM LIMB TREATED BY HIGH CERVICAL CHORDOTOMY

### REPORT OF TWO CASES

BY MURRAY A FALCONER AND JOHN S B LINDSAY

FROM THE DEPARTMENT OF NEUROSURGERY, OTAGO MEDICAL SCHOOL AND THE DUNEDIN HOSPITAL, NEW ZEALAND

THE lot of a patient, who after amputation experiences pain in his missing limb, may become pitiful. Indeed, some of these sufferers have sought release by suicide. Although it is well known that an absent limb commonly persists as a phantom, it is not generally appreciated that it may become the seat of genuine pain, and all too often the unhappy patient is regarded as the victim of a psychological disturbance.

Judging by reports in the literature, the treatment of painful phantom limbs has been for most surgeons a disappointing experience (Bailey and Moersch, 1941, White, 1944). In a few cases the excision of tender end-bulbs on the divided nerves or adherent scars in the stump has proved beneficial. In others interruption of the sympathetic pathways from the limb, either by infiltration with a local anaesthetic or by sympathectomy, has relieved pain. Sometimes, indeed, a single injection of local anaesthetic around the sympathetic ganglionated chain has produced prolonged and even permanent benefit (Leriche, 1939, Livingston, 1938). Unfortunately, however, these simple measures do not relieve all patients, and when they fail the problems of treatment become difficult and formidable. Many procedures have then been tried, but none have gained general acceptance. Destructive procedures on peripheral nerves, nerveplexuses, or nerve-roots, and the intra-arachnoid injection of alcohol, have usually failed (Riddoch, 1941, White, 1944). Division of the lateral spinothalamic tract within the spinal cord has proved successful in some hands for painful phantom in the lower limb (White, 1944), but not in all (Bailey and Moersch, 1941), and recently the operative excision of areas of the sensory cortex has been recommended instead (de Gutierrez-Mahoney, 1944). In fact surgical treatment has failed so often that many authorities regard patients with painful phantom limb as psychoneurotic (Bailey and Moersch, 1941), and some surgeons have even considered performing prefrontal leucotomy (White, 1944), a procedure which is only doubtfully justifiable.

One of the difficulties with spinothalamic tract section has been to secure a sufficiently high level of analgesia, particularly when the upper limb is concerned. To be effective the tractotomy must produce complete analgesia not only of the segmental

levels of the missing limb, but also for a short distance above this. If the lower limb alone is concerned, the necessary analgesia can readily be obtained by anterolateral chordotomy performed in the upper thoracic region. If, however, the upper limb is involved, it is difficult to produce the necessary extent of analgesia by tract section no matter how high the level at which it is performed. This may explain why, when high cervical chordotomy has been tried for painful phantoms in the upper extremity, only partial successes have been observed (Foerster and Gagel, 1932, de Gutierrez-Mahoney, 1944, White and Smithwick, 1942). J C White (1944) with his great experience states, "So far I have had no opportunity to attempt a high section of the spinothalamic tract for phantom pain in the arm, and have been unable to find any successful report of its accomplishment" \*.

It seems appropriate, therefore, to describe 2 cases of painful phantom in the upper limb which were relieved by high cervical chordotomy performed by controlled graduated division under local anaesthesia. Neither had been benefited by previous blocking of the sympathetic and peripheral nerve pathways. Observations were made in them which throw light on the mechanism of pain-production in painful phantom limbs. Together they show that at least some cases of painful phantom upper limb, hitherto regarded as intractable, can be relieved by operation.

### CASE REPORT

*Case 1* —Army corporal, aged 27 years, suffering from causalgia in a phantom hand following traumatic amputation of an upper limb.

\* Since forwarding this paper for publication, we have learnt that Mr Lancelot Bromley has an apparently successful case, which he operated on in 1923 and published in *Guy's Hospital Reports* for April, 1930. The anterolateral column on the contralateral side of the spinal cord was divided at the level of the 3rd cervical segment, while the 3rd and 4th posterior cervical roots were divided on the same side. The patient was completely relieved of all pain in his phantom upper limb. When examined four years later he exhibited impairment of pain sensibility below the 6th thoracic segment, but not above this level.

This soldier, referred in May, 1944, to the Neurosurgical Unit, Dunedin Hospital, by Lt-Col J J Brownlee, NZ M C, had had his right forearm blown off at the elbow-joint by an 88-mm shell twenty months earlier, while he was on active service in the Middle East. In addition, he sustained several superficial injuries in the base of the neck, the lobe of the right ear, and the



FIG 343—Case 1. Photograph after operation, showing appearances of stump as well as the upper limits of area of analgesia

right temporal region from fragments of the exploding shell, but these did not cause residual symptoms. He was unconscious for a minute or two. Four hours later at a C C S his arm was re-amputated through uninjured tissues at the junction of the middle and lower thirds of the humerus. The stump healed promptly without any trace of infection.

From the time of wounding this soldier had complained of a severe, constant burning pain in his phantom right hand. It was most evident in the thumb and index fingers, but from these digits it spread across the knuckles to involve the middle and little fingers, and also radiated to the dorsum of the wrist. Usually the pain was bearable, but at times it became intense. The phantom hand, itself, felt of normal size and shape, except that the ring finger was completely missing. It was connected by a shortened phantom forearm to a phantom elbow perched at the end of his stump. The phantom forearm and hand were held flexed, as in a sling. The phantom fingers could be moved voluntarily, but with great mental effort, otherwise the limb was immobile. At times the fingers would slowly extend spontaneously, and these involuntary movements were associated with agonizing intensification of his pain. Otherwise there were no known aggravating factors, and in point of interest neither morphine nor alcohol appeared to have much influence on his appreciation of pain. He had undergone three secondary operations on his stump for the excision of terminal neuromas and for alcohol infiltration of the major nerve-trunks, all without relief.

This man's files showed he was a brave soldier. He was a well-built, intelligent fellow, who had been regarded with suspicion by psychiatrists "particularly because his pain did not appear to have an anatomical distribution." He had been examined several times under pentothal narcosis, but nothing was found in his past record or in his family history to suggest an inborn tendency to develop undue psychological strain. We were therefore surprised to find on examination nothing to explain his symptoms. His amputation stump was faultlessly constructed, and of normal colour and temperature (Fig 343). At least two small neuromas could be palpated well away from the end of the bone, but though these produced tingling sensations in the phantom when pressed upon, they did not affect his spontaneous pain.

Here, then, was a man of exemplary type, complaining bitterly of pain in a phantom limb, but without any features either in his stump or elsewhere to account for it. We decided to test out the effect of blocking of the sympathetic and peripheral nerve pathways.

The upper three thoracic sympathetic ganglia on the right side were infiltrated each with 10 c.c. of 1 per cent procaine (modified Labat's technique). The right pupil constricted (Horner's syndrome). The skin temperature of the stump recorded by a thermocouple rose gradually within a quarter of an hour from 26° to 32° C, whereas simultaneously the temperature of the corresponding point on the sound limb fell from 26° to 24° C (room temperature 21° C). Although a sympathetic block was thus shown to be present, the pain remained unabated. He, however, volunteered that his phantom hand felt warmer than before the test.

At the end of an hour, and while the sympathetic block was still complete, the brachial plexus in the posterior triangle of the neck was infiltrated with 40 c.c. of 1 per cent procaine. This resulted in complete analgesia and anaesthesia of the stump, including both the anterior and the posterior axillary folds, and also the outer aspect of the arm up to the insertion of the deltoid muscle. The patient said that his pain was still unaltered, although his hand now felt colder. Thus the pain had not been relieved by the measures usually advocated. This failure of response to blocking of the brachial plexus indicated that any further operative attacks on peripheral nerves, and probably on posterior nerve-roots as well, would be fruitless. The man was desperately anxious to be relieved of his pain, and prepared to go to any reasonable lengths. Operative section of the spinothalamic tract was therefore advised.

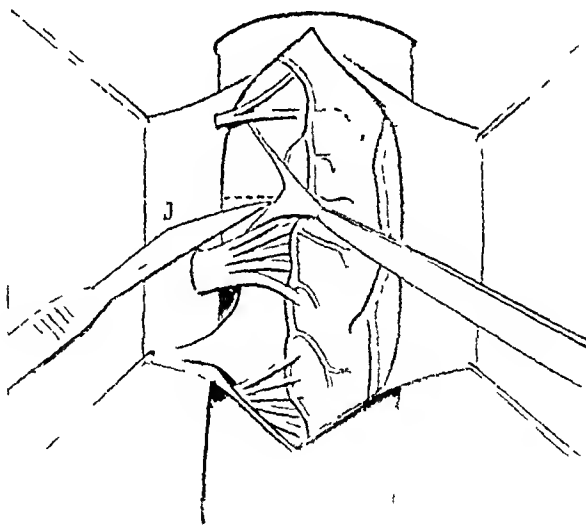


FIG 344—Sketch illustrating procedure of high cervical chordotomy. The slip of the ligamentum denticulatum between the 1st and 2nd cervical nerves has been divided, and the cord rotated preparatory to section of the antero-lateral column.

Laminectomy of the upper three cervical vertebrae was performed under local anaesthesia after preliminary sedation with morphine (gr 1) and with the patient prone. The spinal cord appeared normal. The slip of the ligamentum denticulatum on the left side between the 1st and 2nd cervical nerve-roots was divided, and the cord rotated through about 45° in order to bring the left anterolateral column into view (Fig 344). Next, a tenotome was inserted to a depth of 2.5 mm midway



between the 1st and 2nd cervical roots and about 2 mm in front of the line of attachment of the ligamentum denticulatum, and was then carried forwards until its point emerged on the surface in the line of the anterior nerve-roots. This cut was painless, but we noted that the patient complained of headache whenever arachnoidal strands spanning the subarachnoid space were pulled on, whenever the cord was rotated sufficiently to put nerve-roots on the stretch, or whenever sufficient cerebrospinal fluid was sucked away to dry the cord within the foramen magnum.

This first cut had no effect on the painful phantom, but the anaesthetist reported that it had numbed the body below the anterior axillary fold. It was therefore deepened to between 3 and 4 mm, whereon the patient said that his pain was now vague, and examination disclosed that the inner side of the stump was numbed to pin-prick but not the outer side. A third cut was then made to just over 4 mm deep and was carried forwards to between 3 and 4 mm in front of the anterior nerve-roots (Fig 345). The patient now volunteered his pain was gone. At no stage of the operation was the patient

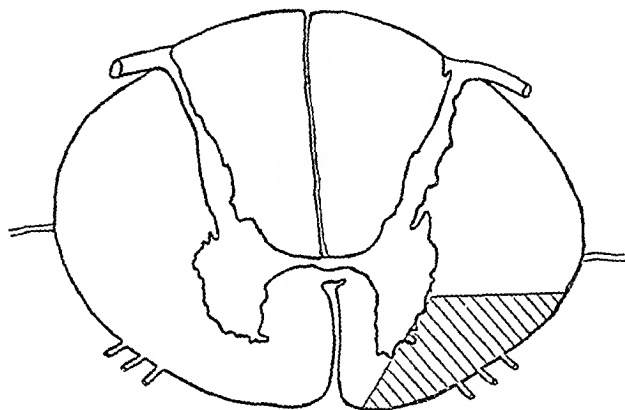


FIG 345—Diagrammatic cross section of the cervical cord to show extent of the chordotomy in Case 1

told of what was being done, or of what sensations he could expect. His behaviour impressed all by its genuineness. During the closure of the laminectomy wound, general anaesthesia was induced with sodium pentothal administered intravenously. The patient's convalescence was uneventful.

Following operation the patient continued to be aware of his phantom, but no longer felt pain in it. He exhibited certain interesting neurological signs. These were on the right side complete loss of pain sensibility, of temperature sensibility, and of tickle sense over the limbs and trunk below the 4th cervical dermatome (Figs 343, 346), and on the left side a Horner's syndrome evidenced by ptosis of the left upper eyelid, by constriction of the left pupil, by gross diminution of thermoregulatory sweating (Guttman's chinazurin method) over the left side of the face, head, and upper limb, with only slight impairment over the left side of the body below that, and by diminution of the pilomotor reflex on the left side of the chest. These left-sided signs suggest that the left tecto-spinal tracts had been divided in addition to the spinothalamic tract. There was no detectable impairment of tactile, postural, vibrational, and 2-point discriminative sensibility on either side of the body, except for a narrow zone of diminished sensibility over the upper part of neck on the left side (> C2 dermatome). There was no loss of testicular pain on either side.

This patient was discharged from hospital 3 weeks after operation. When seen more than a year later, his phantom was still painless and his residual sensory

neurological signs were unchanged. The left-sided Horner's syndrome had disappeared. He was back at work without any disability, other than that due to the absence of the amputated limb.

**Case 2**—War pensioner, aged 33 years, suffering from casualgia in a phantom hand following surgical amputation of an upper limb.

This man, referred by Dr R H Q Baxter, had had his left elbow shattered by a sniper's bullet while serving in Crete in May, 1941. A field dressing was applied, and then under great difficulties he was evacuated to Egypt. By the time he reached Alexandria he had

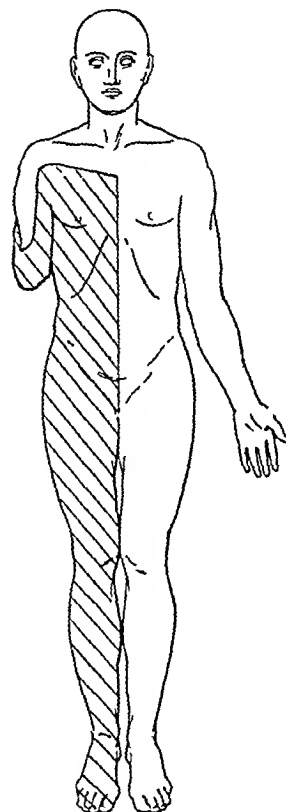


FIG 346—Case 1. Extent of loss of pain, temperature, and tickle sensibility following chordotomy. Touch and postural sensibility were preserved.

developed gas gangrene, and so 8 days after wounding his arm was amputated below the upper third of the humerus. He cannot recall the events of the next month, probably on account of toxæmia. His stump became septic, and more than five months went by before it healed.

As soon as he regained consciousness he was aware of pain in the phantom hand and in his stump. The phantom hand felt a little smaller than the normal, and lay at some distance from the stump. It was, moreover, incomplete, for the only portions which he could definitely discern and in which he could locate his pain were the thumb, which he could identify separately, and the fingers, which he could only group together. These digits were held semiflexed, and kept squirming together continuously. Voluntarily he could move them a little, but the effort made his pain intolerable. The pain also became severe with emotional stress, such as seeing blood-curdling pictures at the cinema or hearing other people discuss their wounds. It was not affected by pleasurable excitement, nor by morphine or alcohol. In addition to the pain in the phantom, there was also a continuous but less severe



ache throughout the stump. A year after wounding he underwent an operation for trimming the stump and excising neuromas, but without relief.

This man's past record and bearing, like that of *Case 1*, were beyond reproach. On his return to New Zealand towards the end of 1941 he had re-entered the Civil Service as a clerical worker, and in spite of his pain had risen to a responsible post. It was in the course of his official duties that he encountered the first patient, and, impressed by the result, he initiated arrangements for his own admission to the Neurosurgical Unit.



FIG 347—*Case 2*. Photograph after operation showing appearances of stump as well as upper limits of area of analgesia. The drooping of the right upper eyelid, the constriction of the right pupil, and the laminectomy incision can also be seen.

On examination little abnormal was found. The stump was well-formed, and of normal colour and temperature (Fig 347). Pin-prick and light touch were felt a little more acutely than usual over the end of the stump, but there was no tenderness. Several neuromas could be palpated, and pressure over some of them caused pain in the fingers. The same investigations were made as in *Case 1*. A procaine block of the upper three thoracic sympathetic ganglia had no effect on the pain, although the block was complete as demonstrated by the occurrence of a Horner's syndrome and by the complete absence of thermo-regulatory sweating in the left face and left fore-quarter. Similarly anaesthetization of the brachial plexus with procaine solution was without benefit.

This man, then, was a case of painful phantom limb similar in most respects to the first. The only points of difference were that the initial amputation had been surgically performed and not traumatic, while his wound had been infected. Although we cannot tell whether pain was present in his phantom immediately following amputation, it was noticed immediately clear consciousness was regained some four weeks later. These differences, we felt, were not fundamental. The same procedure as in *Case 1*, namely, a high cervical chordotomy, was therefore recommended.

The result was similarly beneficial, but incidentally revealed an important hazard in this operation. Laminectomy of the upper three cervical vertebrae was performed under local anaesthesia, and the cervical cord exposed by opening the dura. Rotation of the cord proved slightly more difficult than in *Case 1*, and before it could be accomplished properly the upper three slips of the ligamentum denticulatum on the right side had to be divided. It is interesting that rotation of the cord and traction on subarachnoid strands again caused pain, although sucking out of cerebrospinal fluid this time had no effect. The anterolateral column was then sectioned in stages at the same level as in *Case 1* (i.e., midway between C1 and C2 nerve-roots). Before this could be done a tiny artery on the surface of the

cord which crossed the line of section had to be coagulated with a finely-controlled diathermy current applied via a fine hook, and then divided. The first cut to a depth of 2.5 mm produced analgesia extending up to the 3rd thoracic segment only, and did not affect the phantom. As the cut was deepened the patient said his spontaneous pain lessened, but it did not finally disappear until the point of the tenotome had penetrated the cord to a depth of between 4 and 5 mm immediately in front of the line of the ligamentum denticulatum, and had emerged on the anterior surface 3 to 4 mm in front of the line of the anterior nerve-roots. The cuts were bloodless. The patient now volunteered that he was free of pain, but to our consternation his right arm and right leg appeared paralysed, although just prior to the last cut he had moved them well. The closure was then carried out under intravenous pentothal anaesthesia.

Fortunately within an hour of returning to the ward he once more began to move his right limbs. Thereafter his convalescence was straightforward. He proved to have been completely relieved of his pain, but his phantom persisted. He showed similar post-operative signs to *Case 1*, viz. loss of superficial and deep pain sensibility and of temperature sensibility on the left side below the C3 dermatome, and a right-sided Horner's syndrome associated with diminished thermo-regulatory sweating over the right side of the body, marked in the upper half and only slight below the costal margin (Figs 347, 348).

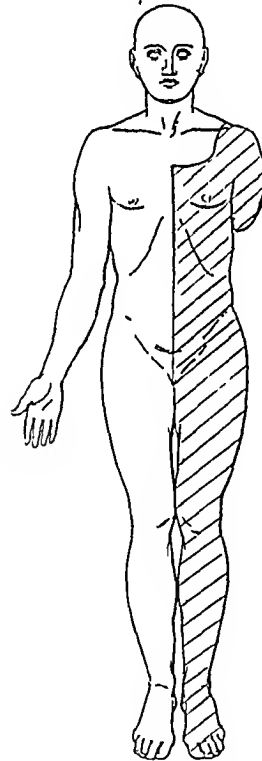


FIG 348—*Case 2*. Extent of loss of pain temperature and tickle sensibility following chordotomy. Touch and postural sensibility were preserved.

Once again the sensations of touch, posture, vibration, and 2-point discrimination were unaffected. Fortunately he had no residual weakness of the right limbs, although the right abdominals were diminished, and the right plantar response remained extensor for three months before becoming normal again.

This man was discharged from hospital three weeks after operation and shortly afterwards resumed work. When re-examined six months later he was still free of

pain in his phantom hand, which in the meantime had receded until it projected from the end of his stump. The Horner's syndrome had disappeared, but the other neurological signs remained. Although he no longer had pain and temperature sensibility below the left clavicle, he remarked that, if he wore rough clothes or had a hot shower bath, he felt an annoying sense of pins and needles in his trunk and left thigh. These sensations were only occasionally present and did not inconvenience him. His only disability was the loss of his limb.

### DISCUSSION

The descriptions of their painful phantoms given by our two patients are similar to accounts of other cases related by Riddoch in his presidential address on "Phantom Limbs and Body Shape," delivered to the Neurological Section of the Royal Society of Medicine in 1941. Fortunately the medical profession and the educated laity are now sufficiently well informed to regard no longer such accounts with disbelief or even with accusations of insanity. The purely descriptive details, therefore, need not be further considered. The more important features are those which throw light on the mechanism of pain production in phantom limbs and their treatment.

Probably much of our confusion of thought regarding painful phantoms arises from failure to recognize that there is more than one cause of pain. Many cases are relieved by interruption of peripheral nerve or sympathetic nerve pathways, but a few, as exemplified by our own two patients, are not. Surely this suggests that in these two groups the mechanisms by which pain is produced are different. It may be profitable, then, to inquire whether there are any other differences between these two groups so that we can learn to recognize and distinguish them more readily, and hence to treat them with greater understanding.

Leriche (1939) points out that usually pain does not appear in a phantom limb until some weeks or even months have elapsed since amputation, and moreover is often associated with burning sensations and with vasomotor and trophic disturbances in the stump itself. The exciting factor appears to be one of irritation of nerve-fibrils either within or around the neuromas which form at the ends of divided nerves. Leriche states that when the nerve-fibrils primarily excited are peripheral nerve-fibrils within the neuroma, pain can be relieved by blocking on sections of the nerve-trunk, when, however, the nerve-fibrils primarily excited are sympathetic nerve-fibrils surrounding the neuroma, pain can be relieved by sympathetic block or sympathectomy. Such a subdivision does not concern us here, for the type of case which we have described is that in which procedures on peripheral and sympathetic nerves prove unavailing, and in which pain appears to arise in nerve-cell stations situated within the central nervous system.

Leriche also describes a small group in which pain in an absent limb appears immediately following amputation, is not associated with any appreciable disturbances in the stump, and is not relieved by infiltration of the appropriate sympathetic and peripheral nerves with local anæsthetic solutions. Our two cases probably belong to this small group, although in only one could we be certain that pain

appeared immediately on amputation. The mechanism of pain production in this group Leriche regards as "inexplicable", and he likens it to "a sort of instantaneous fixation in the memory of a scene suddenly realized and converted into an obsession". In our two cases, however, we have strong evidence that symptoms were not hysterical, for in both during the course of operative procedures the nature of which the patients were unaware of, pain was lost at the appropriate moment.

By infiltrating the sympathetic and/or peripheral nerve pathways with local anæsthetic solutions, we can gain information which will guide us in treatment. Sympathetic block may prove of therapeutic as well as diagnostic value, because relief, even when conferred by only a single infiltration, may be prolonged or even permanent (Leriche, 1939, Livingston, 1938). If, then, there should be a recurrence, the sympathetic block can be repeated or else a sympathectomy performed. Similarly, when infiltration of the peripheral nerve-trunks affords relief, excision of neuromas can be considered. In this connexion Leriche raises a word of caution, for he points out that neuromas will recur, as their formation is the usual repair mechanism after nerve severance, and probably will again cause trouble. He therefore advocates that, instead of excision, the nerve-trunk above the neuroma should be divided and then re-sutured. Boldrey (1943), however, prefers to excise the neuroma, and to bury the stump of the nerve in a drill hole made through a neighbouring bone.

If blocking of the peripheral and sympathetic nerve pathways fails to relieve pain, destructive operations on these pathways will prove useless. Even after such procedures as the extensive division of the posterior nerve-roots and the intra-arachnoid injection of alcohol, the painful phantom persists unchanged, no matter how much the stump may be denervated (Riddoch, 1941, White, 1944). Only two types of operative procedure appear to offer prospects of relief. They are, first, division of the lateral spinothalamic tract, and, secondly, ablation of the appropriate area of the sensory cortex.

Our two cases show that, provided due technical precautions are taken, similarly beneficial results can be achieved by high cervical chordotomy for painful phantoms in the upper limb as have already been achieved by high thoracic chordotomy for painful phantoms in the lower limb. The past failures of high cervical chordotomy are responsible for the suggestion (White, 1944) that division of the spinothalamic tract within the medulla (Schwartz and O'Leary, 1941 and 1942, White, 1941) or even higher still in the midbrain (Walker, 1942) would prove after a trial to be preferable procedures. However, in none of the published reports of these operations does a sufficiently high, and yet complete, level of analgesia appear to have been obtained.

May we digress for a moment to point out how greatly the pain of a phantom limb resembles that which may occur in an intact limb with a peripheral nerve injury and which is commonly described as *causalgia*. The pain of both conditions has the same physical characteristics, and just as cases of painful phantom can be divided into two main groups, so also can cases of *causalgia*. There is first a group in which pain appears to arise in or around the

neuroma with nerve anastomosis or by sympathetic block or interruption. There is also a group which cannot be relieved by such procedures, but which we have found can be relieved by chordotomy. Indeed, for the type of pain which we are particularly considering it does not matter whether the limb is present or not.

The operation of spinothalamic tract section does not destroy the patient's perception of a phantom or of his real limb, but only abstracts from it the sensation of pain. The stump continues to be serviceable for such purposes as bearing harness or carrying an artificial limb. The fact that in this minority of cases spinothalamic tractotomy relieves pain, whereas posterior rhizotomy does not, suggests that the pain-exciting impulses arise in the nerve-cells of the posterior horn of the spinal grey matter, and pass thence via the thalamus to the cerebral cortex, where they are perceived. Possibly these nerve-cells become excitable because they no longer receive impulses from the axons of the receptor neurones in the spinal ganglia. A somewhat analogous phenomenon of spontaneous excitability occurs when nerve-cells in the sympathetic ganglia are cut off from higher control by preganglionic sympathectomy (Govaerts, 1939). Should this hypothesis be true, one might explain the observation of Bailey and Moersch (1941) that digital pressure over the main nerve-trunk above the amputation may cause the phantom to disappear, whereas cutting the nerve will not. Pressure over intact receptor nerve-fibres cut off from normal stimulation by sensory nerve-endings may excite impulses in them which pass up and temporarily control the dorsal horn cells.

So far the deliberate treatment of painful phantom limb by ablation of the appropriate sensory area in the post-Rolandic convolution has apparently been tried in only a single case (de Gutierrez-Mahoney, 1944), although others have considered it. A successful result was obtained, but full details of the case are not given. This type of procedure is based on a clinical observation by Head and Holmes (1911) that a lesion of the parietal lobe, by destroying the recognition of posture, abolishes at the same time the phantom limb. Presumably the impulses which give rise to a phantom reach consciousness in the parietal cortex. This type of operative procedure, when compared to spinothalamic tractotomy, has the disadvantage that it destroys postural and other discriminative sensations in the stump, and so renders the stump functionally useless for such purposes as carrying an artificial limb.

Spinothalamic tract section may thus prove preferable to regional ablation of the sensory cortex. The operation of high cervical chordotomy, however, should not be entered upon lightly, for it can be difficult and laborious, especially in thick-set individuals. It is, moreover, hazardous, as the sudden onset of a hemiplegia in our second case well illustrates. This hemiplegia disappeared rapidly, indicating that the pyramidal tract had not been sectioned, and we do not know how it was produced. Penfield (1943) has described a more serious hazard,

for following this operation under local anaesthesia one of his patients suddenly and inexplicably died.

Nevertheless, when a patient is suffering from genuine and intolerable pain, the surgeon must be prepared to take reasonable risks. There is sufficient evidence to justify further trials of high cervical chordotomy.

## SUMMARY AND CONCLUSIONS

Pain occurring in a phantom limb has the same characteristics as causalgia occurring in an intact limb with a peripheral nerve injury. There are two main groups of cases—a group in which pain impulses appear to arise in or around the neuromas on the divided nerves and can be relieved by excision of the neuromas or by sympathetic block or interruption, and a group in which painful impulses arise in the dorsal horn cells of the spinal cord and can be relieved only by section of the spinothalamic tract or by excision of the sensory cortex of the cerebrum. Infiltration of the appropriate peripheral or sympathetic nerve pathways with a local anaesthetic solution is a useful diagnostic procedure for distinguishing clinically between these two groups. When these diagnostic tests fail to give relief, section of the spinothalamic tract is indicated and seems preferable to ablation of the sensory cortex, because it does not destroy the phantom or the patient's appreciation of his stump, but only abstracts from it the sensation of pain.

Two cases are described which well illustrate these points.

Our thanks are due to Professors W. E. Adams, F. G. Bell, J. C. Eccles, and F. H. Smith for their help and advice, also to Miss M. E. Ogilvie and Mr. C. Weedon for assistance with the illustrations.

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## VASCULAR TUMOURS OF THE SPINAL CORD ASSOCIATED WITH SKIN HÆMANGIOMATA

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ALTHOUGH a number of cases illustrating the association of vascular tumours of the brain with a nævoid condition of the face, known as Sturge's disease, have been described (Nussey and Miller, 1939), and the list is constantly being added to, the analogous combination of a vascular tumour of the spinal cord and a hæmangioma of a corresponding segment of the skin does not appear to have been so commonly observed.

Berenbruch (1890) described a case with three huge congenital angiolipomata over the right pectoral muscles in a boy aged 16, these were situated over the right scapula and latissimus dorsi muscle, there was a large plexus of veins along the spinal column connecting outwardly with an extradural angioma, and with the tumours of the back through the intervertebral foramina. There was an angioma of the cord substance itself from C 5 to D 3.

Cobb (1915) described a case of a boy, aged 4, with congenital nævi, the largest being 5 in in diameter, there were three on the right and one on the left side, in the cutaneous areas of the 7th, 8th, and 9th dorsal segments. A cluster of large pulsating vessels was found on operation, extending from the 4th to 9th dorsal segments of the spinal cord. Cobb therefore suggested that nævi are of diagnostic value when a spinal cord lesion is present and that vascular tumours might be expected to occur in any organ with corresponding segmental innervation.

Alexander (1922) described a case with multiple nævi unrelated segmentally to a coexistent vascular spinal cord lesion.

In Rand's case (1927) a pigmented nævus of the skin of the back, at the lower border of the right scapula, led to a pre-operative diagnosis of hæmangioma of the cord, which was confirmed subsequently at operation.

Kaplan (1935) recorded the case of a woman, aged 27, with an extradural hæmangioblastoma, opposite the laminae of D 5 to D 12, and a nævus just to the left of the 5th to 12th dorsal spines.

Sterling (1936) described a case with a nævus behind the right knee, and a segmentally related tumour of the spinal cord.

Johnston (1938) recorded the case of a boy, aged 5, with a nævus 8 cm in diameter just below the left scapula over the tenth rib, with symptoms and signs pointing to a spinal cord lesion. A sudden exacerbation of symptoms, due, it was thought, to rupture of one of the thin-walled blood spaces of an epidural hæmangioma, at the level of the 10th dorsal segment, was followed by death. At autopsy an extradural hæmangioma was found, extending from the 9th to 10th dorsal segments of the spinal cord. There was a localized area of atrophy of the cord opposite.

Karshner, Rand, and Reeves (1939) described a case, in a boy aged 14, with scattered pigmented

hæmangiomata, especially in the region of the 5th to 9th thoracic dermatomes. A pre-operative diagnosis of vertebral hæmangioma, involving the region of the 7th thoracic vertebra, was made, and on operation a vascular extradural hæmangioma involving the laminae of the 6th to 8th thoracic vertebrae was exposed. The dura was not opened. Pathological examination of this tumour showed endothelium-lined channels filled with blood-corpuscles, lying in a stroma of connective and fatty tissue. They state that it remains questionable whether vertebral and epidural hæmangiomata represent neoplasms or vascular malformations. These are different from hæmangioblastomata, being relatively benign, slow in growth, and not metastatic, with most of the accumulating evidence suggesting a segmental origin.

Ewing (1940) mentioned a case with an extradural angioma of the spinal cord and angioma of both breasts, skin, mucous membranes, and lungs. It is not clear whether the skin angioma were congenital or due to secondary involvement.

Turner and Kernohan (1941) described, among a series of vascular tumours of the spinal cord, an epidural hæmangioma associated with an angioma of the muscles and skin of corresponding metameres. They classify angiomatous growths of the nervous system into true tumours (blastomata) and malformations (hamartomata) though they state that a neoplastic one may have had its origin in the confines of a malformation.

Wyburn-Mason (1943) collected several cases where skin nævi were associated with vascular tumours of the spinal cord. One of these, in a woman aged 22, a case of Jefferson's, had a curious telangiectatic malformation of the subcutaneous tissue, covered in places by a keratinization of the skin (angiokeratoma or angioma verruqueux). The nævi were of two types, one raised above the skin and of an indescribable blue colour, the other flat and more diffuse, forming typical telangiectases. These were confined to the left side of the body and involved three areas—the dermatomes C 8 to D 1, D 7 to D 11, and L 4 to S 3. Autopsy showed telangiectases, mainly confined to the left side of the cord, in neuromeres corresponding to the affected skin dermatomes. He suggests that such metameric nævi may frequently be associated with corresponding lesions of the cord, but are only brought to light when hæmatomyelia occurs, as in this case. He divides lesions into (a) Vascular lesions of the cord, which are either in the nature of telangiectases, cavernomata, or cavernous angioma, the latter with gliosed tissue between the vessels, or hæmangioblastomata with intravascular endothelial-cell proliferation in the telangiectases (this latter is not usually the type associated with skin nævi), and (b) The extradural variety (to which the case described below belongs)—cavernous angioma, with large vascular sinuses,



Fig 349



Fig 350

FIGS 349-352—Photograph showing extent of the naevus  
The operation scar is visible in Fig 352



Fig 351



Fig 352

the walls being formed by endothelial cells, resting on a very loose connective tissue, which contains variable amounts of fat. His view is that there is no direct connexion between metameric naevi and a spinal vascular abnormality, but that their coexistence is due to a developmental disorder of the whole neuromyodermatome, and that neither of these abnormalities is dependent on the other.

#### CASE REPORT

**HISTORY**—F. G., female, aged 47, developed a gradually increasing paraplegia since December, 1943,

both legs being affected equally. She was then resident in London. In August, 1944, in consequence of enemy action, she went to live in the country. Here, whilst using a lavatory, the pan broke, and she sustained an extensive lacerated wound of her left buttock, necessitating the insertion of seven sutures, the wound subsequently becoming septic. Her doctor recommended her to leave the area, and she was evacuated to Birmingham. She did office work right up to the time of the accident. Since, then, however, she has been unable to walk without assistance, or holding on to objects. There was nothing of note in the previous history. Her husband and her two children, aged 24 and 22, are alive.

# CORD TUMOURS WITH SKIN HÆMANGIOMATA

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and well, and there is no family history of an extensive naevus or of nervous disorder

**ON EXAMINATION —**  
**Skin Condition**—There is a congenital purplish discoloration of the skin. This involves the whole of the left arm, forearm and hand, the anterior aspect of the chest, including the breast area, extending from the xiphisternum medially to the 10th rib level in the mid-axillary line below, and to the clavicle above, with, however, a patch of normal skin just below the outer extremity of the clavicle. Posteriorly, it tapers off towards the middle line, where it ends approximately at the level of the 4th to 6th thoracic spines, extending a little over at one place. There is an isolated patch over the spine of the scapula. There are scattered areas of hyperkeratosis, especially in the upper anterior aspect of the chest (Figs 349-352). There is some swelling, probably of a cavernous nature, of the fingers, especially the first and terminal phalanges, and of the distal part of the palm (Fig 353).

On examination of the spine, there was full mobility and no tenderness.  
 A presumptive diagnosis of neoplasm of the spinal cord was made.

**Cerebrospinal Fluid** (Oct 2) gave the following content —

Protein	107 mg / 100 c c
NaCl	734 mg / 100 c c
Sugar	64 mg / 100 c c
Globulin (Pandy, Nonne-Apelt)	trace
Lange	11222110000

There was an average of 1 cell per c c. The CSF pressure was 170 mm, Queckenstedt's test showed a complete block, both 30 mm and 50 mm jugular pressure giving no rise in CSF pressure.



Fig 353—Photograph of hand showing the swelling of first and third phalanges

**Neurological Examination**—Memory for past and recent events was normal, intelligence and speech were normal, and she was of a cheerful, almost euphoric, disposition. Examination of the cranial nerves and nerve-supply to the upper limbs revealed no abnormality. The abdominal reflexes were absent. There was gross loss of power throughout the lower limbs, worse on the left side, with marked increase of tone in both legs. On testing sensation, there was a poorly defined hypoaesthesia, and hypothermæsthesia up to a vague level about the costal margin posteriorly, and to an even less definite level anteriorly. Proprioceptive sense was absent in the big toes and diminished at ankles of the 2nd or 3rd lumbar spinous processes. The lower limbs were cold, the feet bluish and œdematous, with a tendency to clubbing. Knee- and ankle-jerks were exaggerated, patellar clonus, exhaustible, was present equally on both sides, as also was ankle clonus, which was of an inexhaustible type. Both plantar reflexes were extensor. Rossolimo's test was negative on both sides. The reflexogenous zone for Babinski's test extended up to the 10th or 11th dorsal segment on both sides. A pin-prick applied to thighs and lower abdomen caused involuntary withdrawal of the corresponding lower limb.



Fig 354—Radiograph showing a narrow column of lipiodol in lower and mid-thoracic regions, with widening of column in upper thoracic region. This suggests an extensive malformation of vessels along the thoracic cord, especially on the right side.

A further sample on Nov 7 contained —  
 Protein 165 mg / 100 c c  
 Pandy and Nonne-Apelt tests + +  
 Wassermann Blood and CSF were negative  
 Blood-count Red blood-cells 5,290,000  
 Hæmoglobin 108 per cent  
 Colour index 1.02

**Radiological Examination**—Radiographs showed only arthritis of D 10 and D 11 vertebræ, and osteo-arthritis of the sacro-iliac joints.

**Lipiodol Injection**—On Nov 7, 2 c c of lipiodol were injected intrathecally into the L 4 to L 5 interspace. No obstruction was detected on screening. On Nov 12, however, myelography showed a very slow flow of a narrow column in lower and mid-thoracic regions, with a suggestion of widening in upper thoracic region.



an extensive malformation of vessels along the thoracic cord (Fig 354)

*Course*—On the evening of Nov 7 patient complained of much pain in the legs and paralysis of legs and toes, there was also dysuria on this and the following day. Muscular power in the legs gradually improved, but she was still unable to walk with assistance, which she was able to do before the lipiodol. A more definite level of sensory loss was now obtained.

On Nov 22 there was still marked weakness of both legs. She was barely able to do the heel-knee test on

was in a type of vessel which might well respond to X-ray treatment. Haemostasis was therefore secured, and the wound sutured with silk, in layers, two for the muscle and one each for the deep fascia, superficial fascia, and skin, without drainage, sulphanimide powder being incorporated in the layers of closure. Patient was shocked and rather cold after the operation, but soon picked up under the radiant-heat cradle. Healing of the wound was uneventful.

A course of deep X-ray therapy to the mid-dorsal region followed.

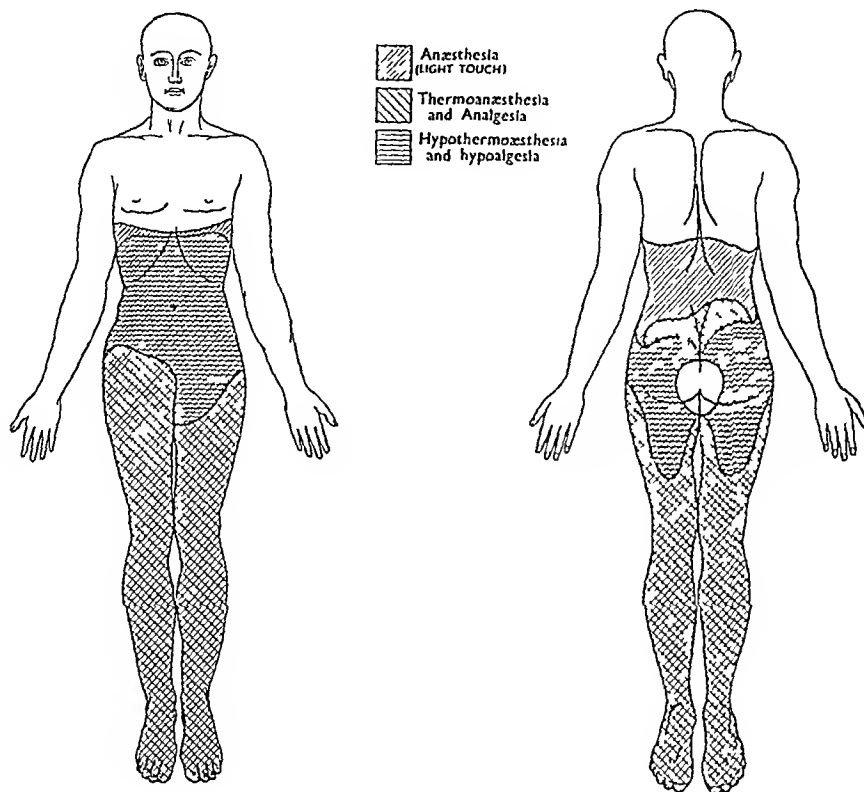


FIG 355—Charts showing sensory changes

each side. There was gross weakness of dorsiflexors in both feet, and of toe movements, left worse than right. There was spasticity of both quadriceps muscles. There was anaesthesia to cotton-wool up to the level of the fifth rib on both sides anteriorly, and up to the eighth thoracic spine posteriorly, with sacral sparing over buttocks only, thermo-anaesthesia and analgesia from L 1 to S 3 on right and L 2–S 3 on left side, hypothermoesthesia and hypo-algesia from posterior mid-thigh up to and including buttocks on both sides, and anteriorly up to level of fifth rib on each side (Fig 355). Rossolimo's test was now positive on both sides. There was normal pin, touch, and thermal sensation over the naevus.

*AT OPERATION* (Nov 23)—Under intratracheal nitrous oxide, oxygen, and ether anaesthesia, a midline incision was made in the upper thoracic region (see scar in photograph, Fig 352) and the laminae of T 4 to T 7 were removed. This disclosed, immediately beneath, a mass of tangled blood-vessels which bulged into the gap made by removing the bone. From its colour the mass appeared to be exclusively venous and there was no marked pulsation. It extended over three full vertebrae and lay outside the dura, both on the right and left of the middle line. Excision or removal of a portion for biopsy was not attempted owing to the risk of haemorrhage. It was thought that the vascular malformation

A radiograph taken some time after the operation, with the patient tilted, showed that although there were still droplets of lipiodol present, none was present above the 9th dorsal vertebra (Fig 356). No abnormal calcifications were present. A radiograph of the chest showed no definite lesion or abnormal vascular markings.

She had oedema of ankles and lower half of legs with trophic changes in both feet for a time, but these gradually subsided and sensation began to return, until, on May 2, 1945, sensation to pin-prick, cotton-wool, thermal, and vibration sense was apparently normal. There was still, however, some disturbance of joint sense. She could stand without assistance, which she was not able to do previously, but was still unable to walk without assistance or holding on to objects. In a few small scattered areas, the skin of the forearm became less deeply pigmented, in contrast to the remainder of the skin in this area.

## DISCUSSION AND SUMMARY

A case is described, in a woman aged 47, of a vascular extradural spinal cord tumour, at the level of the 6th to 10th thoracic segments, whose presence was confirmed at operation, with also a very extensive



congenital naevus, involving the 5th cervical to 10th thoracic dermatomes on the left side

Symptoms commenced eleven months before operation, with acute exacerbations eight months later, and a fortnight before operation, the latter

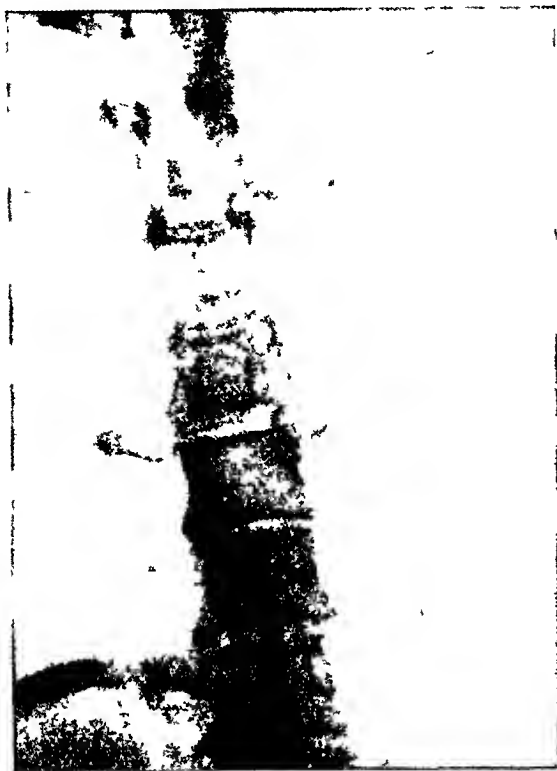


FIG 356—Anteroposterior radiograph of the thoracic and upper lumbar spine, showing absence of laminae of T 4-7 and lipiodol up to T 9 only

following lipiodol injection. Discontinuity and progression by a series of apoplectiform stages or 'episodes' is characteristic of vascular tumours of the spinal cord.

The possibility of the presence of a vascular abnormality in the corresponding segment of the

spinal cord should be kept in mind in patients presenting themselves with signs and symptoms of a spinal cord lesion when there is a naevus of the skin. Though malformations of the spinal cord, due to a disturbance of mesenchymal development, similar to and usually in the same segment as that of the skin condition may be present, their presence may not be suspected until either hæmorrhage occurs or they increase in size, at any time, as in the case described.

The cases recorded in the literature are reviewed, most of them are of a simple hæmangiomatous nature, corresponding to the skin condition, rather than hæmoblastomatous.

My thanks are due to Dr Williams-Walker, under whose care the patient was admitted to the Midland Nerve Hospital, for his kind assistance in the preparation of this paper, to Mr W H Sweet, Neurological Surgeon to the Hospital, who performed the operation, and who kindly allowed me to use his examination and operation notes, and to Dr J F Brailsford for the X-ray examinations.

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## THE MANAGEMENT AND SURGICAL RESURFACING OF SERIOUS BURNS

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THIS paper is based on the management of a series of consecutive serious burns and the resurfacing problems presented by 192 of them.

The immense number of burns in this war has been chiefly due to petroleum products, phosphorus, and cordite, which in that order are the commonest causes of military burns. The problem which a burns casualty presents to the surgeon is a different one in each of the three phases, early, intermediate, and late, through which all serious burns pass. In each of the three Services, too, the burns problem has its own emphasis.

The Navy is faced often with the task of providing primary treatment for a large number of serious burns at the same time, and often under the most difficult circumstances. The R A F have from the first had a special interest in the burns of exposed parts of functional importance—the hands and face. No special type of burn is peculiar to the Army, but Army hospitals, especially those in the Mediterranean theatre, probably see more of the extensive petrol burn with very large areas of skin destruction than are seen elsewhere, the majority of these are the result of accidents.

Treatment in the primary phase of a burn is concerned chiefly with the preservation of life and prophylaxis of infection. The majority of military burns have their primary treatment at Casualty Clearing Stations in quiet periods, or at General Hospitals. The theatre treatment of the battle casualty burn must be simple. It consists usually of "toilet, S V G". This is effective for most superficial burns, and little later treatment is needed. When the full-thickness of the skin has been destroyed, the primary phase is followed by the intermediate and late phases of burns treatment with which this paper is concerned.

The intermediate starts in the second week. It is the period of healing of the burn, and comprises the preparation of the patient and of the burnt area for grafting, and the application of grafts and their care until healing is complete. Surgery in the late phase, that of rehabilitation, is necessary only for that minority of burns which primary cover does not give the best functional result. The ideal treatment is to cover the raw area as early as possible with new skin which will meet the full functional and cosmetic need of the part, but a granulating surface will not always accept a thick free graft, and a thin graft always contracts later. Because of this, some areas such as hands and face must be treated in two stages, a primary cover is provided by thin free grafts which are later excised and replaced by thicker grafts or flaps to relieve the disability of the thin tight primary cover.

**Material on which this Paper is Based**—For two years all serious burns reaching Main Base (first in North Africa and later in Italy) were referred to this unit, 800 cases were treated. Of these, nearly 25 per cent involved the full thickness of the skin and were grafted. This paper describes the management of these 192 cases and the resurfacing problems of their intermediate (or healing) and late (or rehabilitation) phases.

The policy of the unit is to retain all cases until healed, each case is then assessed with reference to his capacity for duty in the Mediterranean theatre. Sun sensitivity of recently healed burnt skin is common in the Mediterranean and makes many cases unfit for further service there for at least 3–6 months. Thus only 16 per cent of the 192 cases with full-thickness skin destruction returned direct to duty in this theatre.

The burns came from all three Services, but Army personnel accounted for 80 per cent. Over 80 per cent of all cases had their primary treatment elsewhere. In North Africa the time of arrival of cases varied between 1 week and 6 months, in Italy the interval has been more uniformly 1–3 weeks, but in a number of cases was 8 weeks or more.

Of the 150 cases admitted to the Unit within 24 hours of being burnt, nearly 100 came from naval incidents caused respectively by phosphorus, cordite, and superheated steam.

Table I shows the incidence of causes of burns with full-thickness loss. The battle casualties are higher in this group (40 per cent) than in the total burns, of which they constituted only 30 per cent. The reason for this is that phosphorus, shell, and grenade burns almost always destroy the full thickness of the skin, and in tank burns there are often

associated wounds and delays in treatment which predispose to secondary infective loss.

Table I—INCIDENCE OF CAUSES OF BURNS WITH FULL-THICKNESS LOSS

<i>Accidents</i>		
Petrol	45 per cent	} 59 per cent
Other	12 " "	
Electric	2 " "	
<i>Battle Casualties</i>		
Phosphorus	16 per cent	} 41 per cent
Tank	11 " "	
Cordite	6 " "	
Petrol (battle)	6 " "	
Chemical	2 " "	

Table II—EXTENT OF 192 BURNS WITH FULL-THICKNESS SKIN LOSS

Per Cent Body Area	Per Cent Incidence
0–10	28
10–20	32
20–30	18
30–40	10
40–50	5
50–60	5
60–70	1
70–82	1

The extensive nature of most of the cases in this series is shown in Table II. Seventy-two per cent involved over 10 per cent of the body surface (that is, more than half the whole lower limb, or both hands and head and neck). In 20 per cent of the cases one-third or more of the body surface was burnt. All these were Army personnel and almost all of them were treated in Italy. In North Africa very few burns of over 30 per cent body surface reached Algiers from Tunisia. Everyone of the 13 cases which involved more than 50 per cent of the body surface was caused by petrol.

Table III—ANALYSING 192 CASES ACCORDING TO EXTENT OF FULL-THICKNESS SKIN LOSS

Area of Full thickness Skin Loss	Percentage Incidence
sq cm	
0–100	16
100–300	34
300–500	15
500–1000	12
1000–2000	17
2000–5000	6

Table III classifies the cases in this paper according to the extent of the full-thickness skin loss. This classification has been made without reference to the site, as the problems of resurfacing special areas are considered separately. A primary concern of this paper is to show that the size of the granulating area is a major factor in the programme of treatment, but not in the time taken to heal it. The cases described here are predominantly extensive areas of skin loss. 68 showed over 500 sq cm loss. In 46 the loss of skin was over 1000 sq cm, that means, for example, almost total loss of the whole skin on a normal-sized thigh with the exception of a strip about 10 cm wide along the outer side, where the skin is thickest, or the whole of the back and parts of the sides of a thigh, popliteal fossa, and calf, or most of the back from the base of the neck to the lumbar region.

The clinical problem in these extensive cases is far wider than that of grafting alone. Almost every patient with 1000 sq cm or more of raw granulating

surface is constitutionally ill until his raw area is substantially reduced below this figure. The upper limit of granulating area compatible with life is not known, but in this series there were 4 cases with 3000–5000 sq cm granulating, all of which survived.

The incidence of severe complicating conditions in these cases was high. The 46 cases with over 1000 sq cm of full-thickness skin loss included 1 with severe typhoid, 4 with infective hepatitis, 6 with severe malaria, 1 with acute glomerulo-nephritis, 1 with glandular fever, 5 with blast lung, and 3 with fractured femur.

## PRINCIPLES OF TREATMENT

**General Treatment**—The main purpose of early treatment is to restore circulation. This is done chiefly by liberal administration of fluids. Progress is controlled by 3-hourly hæmoglobin, blood-pressure, and pulse records for the first 24–72 hours, and by fluid balance sheets.

Hb of 140–150 per cent is not uncommon a few hours after severe burns and the systolic pressure may be 40 mm of mercury or below. There is evidence, which our material confirms, that this combination can cause renal anuria which never recovers, though the B P and Hb are returned to normal within a few hours, by prompt energetic treatment. This consists of fast plasma transfusions which are slowed down when the Hb returns to 100 per cent. The patient is usually thirsty and should be given plenty to drink.

Within a week profound anæmia commences and is treated by repeated blood transfusions of 1–2 pints several times a week, aiming at an average Hb of 80–90 per cent. In cases of extensive skin loss it may be impossible to reach this Hb per cent, however intense the transfusion programme, and improvements following transfusion are likely to be temporary. With healing of the granulating surfaces by grafting the patient becomes independent of transfusion.

As soon as they can take it, the patients are put on a special high-protein, high-sulphur, high-calorie diet, consisting largely of steak and eggs, with champagne, brandy, ice cream, and iced fruit juices. Additional iron and vitamin C are given as medicines. Neglect and ignorance are the only causes of gross emaciation in burnt patients. They are often helpless and incapable of feeding themselves and must be as patiently and attentively fed as they are nursed. Given a full, palatable, and balanced diet with a rapid resurfacing programme emaciation does not occur. Once they are healed the protein and nitrogen loss ceases and a good appetite restores the metabolic balance.

It has been our practice to use penicillin only for a definite purpose, such as the preparation of the surface for grafting or the treatment of some susceptible complication.

In summer flies and heat are a problem. Apart from the discomfort they cause, they both threaten life and are controlled only by air-conditioned, fly-proof wards. It is also important not to overheat the patient by covering him with cotton-wool dressings from head to foot. As soon as the patient is fit enough, a physiotherapist starts work to encourage recovery of function and prevent contractions.

Hands, neck, and eyelids are the most important objectives at first, and later large joints and re-education in walking. The saline bath is very valuable in re-establishing limb movements in extensive burns.

**Evacuation and Travel of Burns**—Burns travel well in the first few hours and all considerations should be subordinated to getting them within 6–12 hours to a General Hospital which can hold them, and give them full services.

If early evacuation is not possible the important thing to realize is that, after their first theatre treatment and anæsthetic, severe burns travel very badly and must be held for several days. Most severe cases are quite unfit for any journey by air or ambulance for a week after operation, and continue to be so, long after they are in need of the full facilities of a General Hospital. The choice of time of evacuation to a General Hospital can be one of great difficulty and ultimately depends on the response of the individual burnt, but any serious case and all affecting 30 per cent area of the body should be held forward for 7–10 days after primary theatre treatment. Circulatory collapse during transit is common in the ill cases and, if they have to be evacuated, they should have a plasma drip running under supervision.

**Local Treatment**—The standard local treatment of all cases in Italy and most of those in North Africa, has been a dressing of S V G after an initial gentle toilet with removal of dead skin, generally after pentothal anæsthesia. The method cannot be called ideal, there are serious objections to swathing a patient in vaseline and wool, particularly in hot climates, fluid loss from the burnt surface is not controlled and bacteriostasis is incomplete and not persistent. In phosphorus burns there has been evidence that early removal of the particles and neutralization has averted full-thickness skin loss in some cases. We have not used the method of cotton-waste compression.

## SIGNIFICANCE OF DEPTH

Much of the confusion of thought that envelops the subject of healing of burns arises from failure to make the critical diagnosis between burns involving partial skin thickness and those with destruction of the whole thickness of the skin. The former may be expected to heal naturally in 1–5 weeks, the time depending mainly on the depth to which the skin is burnt. The latter, however small, are almost invariably best treated by a skin-graft, and it must be clearly realized that an indecisive expectant policy in these cases delays healing inexcusably and often causes permanent crippling or death to the patient.

The management of a burnt patient has thus two main aspects: first, the metabolic problem, and, secondly, the diagnosis of full-thickness skin loss. Early diagnosis of full-thickness skin loss is imperative because once it is made, all attention must be focused on preparing the patient and the surface for skin-grafting as early as possible. It is well here to state the time-table to which local and metabolic treatment must be geared, so as to shorten the painful and dangerous stages to the minimum, by achieving rapid surgical resurfacing, twelve to eighteen days after burning the areas of full-thickness

skin destruction can be accurately assessed and the sloughs excised under anaesthesia. Two days later, close-packed, thin patch grafts are applied and one or two further applications of patch grafts may be needed for extensive burns at two- to three-day intervals, three to seven days after the last grafting operation the patient is healed—that is, on the twentieth to thirty-fifth day after injury. This rapid time-table can be followed in the majority of cases, including many very extensive burns, and is the standard to be aimed at always. As explained below, however, it requires close team-work and supervision, and in a proportion, particularly of complicated cases and those seen later, primary resurfacing is not complete until forty to sixty days.

### CLINICAL DIAGNOSIS OF DEPTH

In taking the history it has been our routine to make notes of the agent and circumstances causing the burn, to record what the patient was wearing, and if his clothes caught fire. It is not surprising that patients' estimates of the length of time that they were being burnt are erratic, but it is generally true to say that a petrol-vapour explosion lasts only a second or so and causes only epidermal burns.

The flash of burning cordite may last up to seven seconds and usually causes dermal burns with patchy full-thickness loss. Burns with large areas of full-thickness loss generally give a history of prolonged exposure to the flames—roughly thirty to three hundred seconds—due to being splashed with flaming petrol, trapped in a blazing tank, wearing petrol-soaked clothes, or being unconscious or helpless at the time of the burn. These are cases of whole-thickness skin destruction caused by the initial severity of the burn.

Phosphorus particles from incendiary weapons typically cause sharply demarcated scattered areas of full-thickness loss, or sometimes larger areas if the clothes catch fire.

Even a single layer of clothing gives good protection from burning, but if the clothes catch fire, full-thickness burns generally occur, unless they are taken off immediately. In contra-distinction to pilots, tank crews wear little protection from flames. For this reason unnecessarily severe burns of hands and face are common amongst them.

In the Mediterranean theatre the difference between summer and winter clothing produces an interesting seasonal variation in the incidence and distribution of the burnt areas. In summer it is common to see a burn confined by a sharp boundary to the parts left uncovered by shirt, shorts, and hose tops. The clothes did not catch fire and there is no doubt that gloves and battle-dress would have completely protected all except the face, but when soaked with petrol, a battle-dress burns fiercely, it is difficult to take off in a hurry, and typically causes very deep burns of the entire trouser area.

Electric and hot-water-bottle burns have always involved full-thickness skin destruction.

Some idea of the depth of a burn may thus be gained from the history, but accurate assessment always depends on recognizing the appearance of burns of different depths. For simplicity we recognize three chief depths of burn, each of which is distinct in prognosis and treatment.

**Epidermal (E B)**—This is the burn caused by minor scalds and momentary explosions, a stage of erythema is generally followed in a few hours by the appearance of lax superficial vesicles or bullae of serum. Under these is the familiar red, exudative, painful skin. Treatment is aimed at comfort and the avoidance of bacterial infection, the burn is dry within a week and leaves no permanent mark on the skin.

**Full-thickness Loss (F T L)**—This term is self-explanatory. In the grossest examples the skin may be initially charred, and in these cases there is invariably heat coagulation of deeper structures, but usually the heat has been sufficient to produce coagulation necrosis of the whole thickness of the skin, and not intense enough to dry it up. Commonly the dry epidermis may be wiped off exposing the underlying parboiled skin. It is most important to realize that it is not possible to diagnose the exact area of full-thickness destruction from this appearance. The parboiled skin is at first a cyanotic red colour or dead white and insensitive to touch, in striking contrast to the raw area of E B. Within a few hours it is surrounded by gross inflammatory subcutaneous oedema, and in a few days it becomes yellowish and the central parts tend to dry up to form a dark-brown leathery slough. Deep to this and at the margins, a plane of separation appears by about the twelfth to eighteenth day and the slough loosens by phagocytic digestion, which causes the accumulation of a lake of pus beneath the slough. The retention of this pus in contact with a large raw area is responsible for the toxæmia and fever which occur at this stage, and it is obviously beneficial to hasten removal of the sloughs surgically.

Within two days of early excision of the sloughs the surface of the subcutaneous fat becomes firm, red, and finely granular, and is ideal for grafting. If the sloughs are allowed to separate naturally they may take twenty-five to forty days and then a smooth glistening gelatinous resurface, with a fibrous reticulum is left. This is best prepared for grafting by daily hypertonic saline dressings, but if treated by infrequent dressings or encased in plaster, the granulations hypertrophy and project above the surface of the skin as a gelatinous friable sheet which is not a sound bed on which to apply free skin, but is usually best removed by abrasion under anaesthesia before grafting.

**Dermal (D B)**—This group is intermediate between the two former and includes all burns in which skin destruction extends through the malpighian layer into the dermis, but not deep enough to cause total epithelial destruction. It is a clinical group of great importance. At first, the appearance of the cyanotic or white layer of shiny moist skin beneath the epidermis may be identical with that of F T L, and though patches of F T L may be rightly suspected, they cannot be accurately mapped out until the separation of a thin and sometimes cheesy slough commences at about five to ten days. The surviving gland and hair follicles then give the surface a stippled appearance which is characteristic and the skin may be expected to heal naturally three to five weeks from the date of burning. In the deepest burns of this group, survival of the epithelial foci is precarious, infection of the area may convert

it into one of full-thickness loss and must be avoided by frequent dressings with scrupulous care. It is our impression that secondary infective full-thickness skin loss is common, but that it usually occurs in cases where skin loss requiring a graft is already present and in not more than 1-2 per cent of burns that are initially part thickness in depth.

The healed skin of dermal burns is thin and delicate, often has an irregular surface, readily vesiculates and becomes abraded or cracked. It is itchy and very sensitive to sunshine and has a sluggish circulation, especially in dependent extremities in cold weather. It is at first very vascular but later pales.

During the first few months after healing, the skin becomes thicker, chiefly by the deposition of a dense dermal fibrous layer. This process is accompanied by a strong tendency to contraction of the scar, which may cause serious deformities and limitation of joint movements, or may convert the affected part into a tight stiff plaque.

In the course of time the layer softens, but the skin never returns to its normal thickness and elasticity. Pigmentary changes and sensitiveness to sunlight may remain for life.

For these reasons dermal scars in some sites may require late plastic repair.

### PREPARATION OF THE SURFACE

The object is to make all areas of full-thickness destruction ideal for grafting as soon as possible.

As soon as the area of FTL can be accurately assessed—generally early in the third week—it is to the patient's advantage to have all sloughs removed from the area by scissors and knife. Haemostasis is then obtained by hot flavine-gauze pressure dressings, and on their removal under a further anaesthetic two to four days later, the surface is ideal for grafting. It is a firm, flat, smooth, red bed which bleeds slightly on removal of the dressings. If light insufflation with penicillin powder or intramuscular penicillin is used, the surface is even more receptive and the take of the graft is almost invariably 95 per cent or over.

Operative removal of the sloughs is not often practicable before 12-18 days, and the earlier it is done, the more hæmorrhage and trauma it causes. Excision of sloughs from very large areas (2000 sq cm and over) may cause serious circulatory collapse and should only be done in these cases by an operating team and anæsthetist with experience in assessing their fitness, and with a good blood service. Where it can be applied on sound skin a tourniquet will reduce the amount of blood lost during the operation. Closed-circuit cyclopropane anaesthesia is very suitable and safe. The operative method requires a minimum of ward work, the preparation of the surface for grafting is done in the theatre 2-3 weeks after the date of burning, daily ward dressings are needed for about a week after the final graft, and the patient is then healed and ready for evacuation, or whatever his correct disposal may be. This time-table heals a burn with maximum certainty in a minimum time—about twenty to thirty days from injury, but some of the most severe and complicated burns are too ill to stand it and must be handled carefully at a slower pace. The method

is economical of hospital beds and skilled ward care, but it demands close supervision by the surgeon and the additional burden on the theatre may make it impracticable. For example, at one period of peak pressure of maxillo-facial work, there were also 90 serious burns in the wards.

The second principal method of preparing the surface is the non-operative one and consists in assisting the natural separation of the sloughs. Its particular value is to relieve the theatre at exceptionally busy periods, and in these circumstances it has largely been entrusted to the ward staffs. The result of this method is undoubtedly that grafting and healing are delayed and the skin is less stable, and each case in the end takes twice as much work to heal it. The method demands great patience and skill and needs a large ward staff. The burn is dressed daily or more often with meticulous technique and at every dressing all marginal crusts, discharges, dead matter, and loosening sloughs are carefully removed. The surface is wiped dry with gauze pledgets, bathed with flavine solution, and covered with a single layer of vaseline-gauze (to prevent pain in removing the dressing). Outside this is a thick layer of gauze soaked in sod sulph 12 per cent in flavine 1-1000, and pressure applied with a crêpe bandage over wool. This method produces a firm layer of flat granulations, with little discharge and suitable for grafting, in two to five days or as soon as the sloughs are off—twenty-one to thirty-five days from the burn. A daily warm normal saline bath to soften the sloughs and assist the separation is of great value. Its proper management is a highly skilled technique and to some extent a physical ordeal, for in badly burnt patients it occasionally causes collapse. Daily light insufflation of the surface with penicillin powder shortens the time required to prepare the surface for grafting and increases the percentage take by reducing the discharge and removing the hæmolytic streptococcus.

When cases of very extensive burns are first referred for grafting long after the separation of the sloughs, and the granulations are hypertrophic and œdematous, the same method applies, but as they have generally also had a long period of malnutrition and toxæmia, it is often wiser to accept the disadvantages of preparing the granulations by hypertonic dressings, than to endanger life by excising them. In many smaller areas, however, the treatment by radical excision or abrasion is better and without risk.

The operative and non-operative methods have both been used in the series analysed here, and several times the two methods have been used in different parts of the same raw area, so that exact comparisons have been possible. The over-riding reason for preferring the radical theatre preparation is that it is short and painless.

### CHOICE OF METHODS OF PRIMARY GRAFTING

It is widely accepted that in grafting granulating areas there is a risk of failure. This can be reduced by correct preparation of the surface, so as to reduce discharge and infection, it is equally important to determine the best method of skin-grafting. The

types of graft under consideration are patch, sheet, and pinch grafts

It is found in practice that the thinner a split skin-graft is, the more likely it is to take on an unfavourable surface. At first a free graft is nourished by direct diffusion from below, in some cases this may be enough for the whole thickness of a thin graft to live, yet if the graft were thicker, only the deeper layers would survive. This conception explains the surface necrosis and desquamation sometimes seen in thick free grafts, and the reliable take of thin grafts.

**Patch Grafts**—For very large areas that must be covered as quickly as possible by a simple safe operation, multiple thin patch grafts are at present the best method. A certain take of 90–100 per cent can be obtained even on an indifferent surface.

The success of patches makes it reasonable to expect that a primary cover by suspension of minced skin may become practicable.

**Sheet Grafts**—For limited areas requiring strong supple skin a 'primary-final' repair may be obtained by a successful sheet graft, but it must be emphasized that there is a tendency for late contracture in all grafts placed on granulating surfaces, that the method calls for a higher standard of preparation and technique than when patches are used, and that it is impracticable to cover some of the largest burns by sheets because of the amount of donor skin required. A 50 per cent gum acacia glue applied to the raw surface of the graft in a thin film is used to secure it and promote a good take. It is as effective as Sano extracts and less trouble to prepare.

**Pinch Grafts**—Pinch grafts have no place in this scheme. They can undoubtedly take readily and need no skill in application, but in every instance patch grafts are better. Patches produce quicker and more certain healing of better quality and appearance, and the donor areas are practically without scar and can be used again and again.

## OPERATIVE NOTES

**Cutting and Application of Patches**—The two chief graft-cutting instruments are the Padgett dermatome and the Blair knife. The dermatome is almost indispensable when the usual donor sites are not available. It is also very suitable for cutting large thick sheet grafts of uniform depth in late repairs, but for patch-graft cover of granulating burns, hand-cut skin is preferable as the dermatome cannot cut the skin as thin as is desirable, leaves scars which take longer to heal because they are deeper, and the dermatome cannot use a donor-site as completely at one session as can be done by hand. For example, we cannot cut skin thinner than 1.0 mm satisfactorily with a dermatome, and at that thickness the graft is difficult to handle and generally tears during removal from the drum. With a Blair knife, it is easy to cut 1000 sq cm of skin from one thigh at one operation, but it would be very difficult to cut the same amount from one thigh—the equivalent of five full drums—with a dermatome. We believe that the best skin for patch-grafting granulating areas is the thinnest that can be cut. Very thin patches coalesce more rapidly and the scar is more uniform than when thick ones are used. The durability of the graft depends less on the

thickness of the patch than on the intervening areas. That is why it is desirable to graft on a firm flat bed and to place the patches so close that they coalesce within three to seven days.

Sheets of split skin are spread on vaseline paper, cut in strips and then into patches of 1 sq cm or less. They are best placed so close together that they are touching, when there is not enough skin for that, they should be cut very small and spread uniformly over the area.

When a dermatome is used as patches on greased paper, it is unnecessary to remove the cement from the sheets as the paper can be removed easily on the fourth day without tearing the grafts. In extensive areas 3–700 patches may be cut and applied at one session. The time taken to apply such a large number of patches can be considerably shortened if a third person is washed-up, and this extra help should be made available for all cases. The operation then takes about 100 minutes for some 400 patches.

It is a wise plan to cover approximately 1000 sq cm at each operation by closely-packed patches. For areas larger than this the operations are staged at 3- to 7-day intervals and are repeated until it is certain that healing will be complete in 10 days.

On the limbs and on most parts of the trunk, these patches are fixed only by a vaseline gauze layer over which flanne-gauze, wool, and crêpe are applied in that order. Fixation of the axilla is a special problem. Here some degree of graft loss due to slipping of the patches has often been seen. Tulle gras fixed to the skin by stay sutures and compression over flanne wool has been found the most satisfactory solution.

**Anæsthesia**—Cyclopropane has been used for all the ill cases since it became available. It has been very nearly ideal with seriously ill patients and they recover consciousness completely two minutes after a two-hour operation.

Continuous pentothal is contra-indicated for all cases of severe burns, most of whom have some degree of liver damage. When this method was used it caused profound post-operative coma and hyperthermia in several cases. One such case died. No harm has ever followed induction with 0.5 g of pentothal or less.

## PRIMARY COVER OF SPECIAL AREAS

There are certain sites where patch grafting is inapplicable as a primary cover and others where it is not the best method. In sites such as eyelids, the hands, and the flexor creases, sheets have been used. They are cut thin and well incised. Incisions are made by uniform stabs with No 11 or No 15 B.P. blade when the graft is spread on the board.

**Eye-lids**—In burns with full thickness of the skin of the lids with dry corneæ the need for tarsorrhaphy to prevent corneal ulceration is urgent. In this series 8 primary repairs of lids for such cases were done after the fourth week, and while the lids were still granulating. The lids were mobilized, tarsal borders brought into apposition, lateral and medial tarsorrhaphies performed and the raw area covered by a thin split-skin graft. In every case the tarsorrhaphy held and the grafts were 90–100



per cent take Although this operation keeps the cornea moist and preserves vision, the cosmetic appearance of thin split-skin grafts is inferior to that which can be obtained later by full-thickness post-auricular grafts

**Hands**—The skin loss in burnt hands demands replacement within 3-4 weeks of burning if contractures and fibrous and secondary necrosis are to be prevented, and if healing is not to be indefinitely delayed No attempt has been made at primary excision of destroyed skin because of the difficulty at this stage in ascertaining early what is dead, especially in burns affecting tendons and joint capsules With efficient chemotherapy delay of excision of sloughs for a fortnight carries no risk of secondary infective loss Between the second and third week a thorough excision of all dead tissue is done under a pneumatic tourniquet This is followed by 3-4 days' light compression and elevation of the limb, with a full course of parenteral penicillin The raw area is then covered with well-incised dermatome sheets cut at  $10\frac{8}{10}\text{cm} \times 10\frac{1}{10}\text{cm}$  and fixed with gum acacia Active movements are started a week after grafting

There is no doubt that sheets are the best primary cover for hands, but for certainty of take in primary operations they must be cut thin These thin sheets undergo considerable contraction which may necessitate later replacements by thick ( $10\frac{1}{10}\text{cm}$  in) dermatome sheets which contract less

The primary repair of a burnt hand by a sheet is a specialized job, and considerable experience in cutting and fixing of grafts is necessary for a consistent standard of success The implication of this is that an alternative simpler method can be accepted under certain circumstances because of the absolutely necessary need of providing a skin cover within a month in extensive deep burns of the hands For this reason there is a role for patches in the primary repair of hands They are an almost certain method of providing a cover within 7-10 days of the graft Like thin primary sheets they have later to be excised and replaced by thick skin before full function can be regained, but once a hand has been given a substantial skin cover the prevention of deformity by using a properly constructed splint at night is a simple matter Supervised active movements during the day can be started within a week of grafting

**Flexor Creases (Popliteal and Cubital Fossæ)**—The healing of patches across the flexor creases may be unstable For this reason sheets of  $10\frac{1}{10}\text{cm} \times 10\frac{1}{10}\text{cm}$  have been used to cover popliteal and cubital fossæ even when contiguous raw areas were covered by patches

## LATE DEFINITIVE REPAIRS

Late repairs formed only 10 per cent of the operations in this series They were short-term operations for cases likely to return to duty in the Mediterranean theatre within three months of primary healing These operations were done for the repair of hands, eyelids, and noses, and consisted of thick dermatome sheets ( $10\frac{1}{10}\text{cm}$  in and thicker) for faces, hands, and popliteal fossæ, post-auricular Wolfe grafts for eyelids and eyebrows,

rotation flaps for axillary and neck scars, and forehead flaps for noses

## LOCAL COMPLICATIONS

The complications to be considered are infective, cicatricial, and dermatological

### Infective Complications—

**Early Infective Graft Loss**—In North Africa the hæmolytic streptococcus was by far the commonest cause, it accounted for partial and occasionally complete graft loss in 15 out of 119 operations (12 per cent) Shortly after the Tunisian battle, there were 10 cases in our burns ward which were heavily infected with sulphonamide-resistant hæmolytic streptococci and had been unreceptive of free grafts despite repeated radical surgical attack All showed a very poor marginal epithelial ingrowth, which is a most important factor in assessing whether free grafts are likely to take well When a brisk epithelial response is present at the margin of a burn, grafts may be expected to take, even though cultures persistently show hæmolytic streptococci Most of these burns were cleared of streptococci by local penicillin when supplies were available, but 5 were evacuated to U.K. still incompletely healed In Italy, since the routine use of local penicillin, streptococcal infection has ceased to be a major concern All cases admitted with streptococcal infection present have been cleared of it after two or three daily applications of penicillin, and the burns ward has been completely free from streptococcal infection for weeks at a time

Use of penicillin has raised the expectation of over 80 per cent take of grafts from 84 per cent (119 cases) to 96 per cent (176 cases), a figure which is capable of further improvement by still greater pre-operative care

About 10 per cent of the North African burns in this series were infected with morphological K.L.B. None showed systemic toxicity, but two shell wounds infected with morphological K.L.B. which were under our care had peripheral neuritis, pathogenicity tests were not available At one time four K.L.B.-infected burns showed a late progressive rot of grafts which had initially taken well All were given 40,000 units of A.D.S., after this, fresh skin-grafts were applied, took well, and remained stable

The other organisms commonly found in burns—*Ps. pyocyanea*, *B. proteus*, staphylococci, and diphtheroids—are all controlled by the regime of frequent ward and theatre toilets and hypertonic pressure dressings, and have not appreciably affected the take of our grafts

**Late Graft Loss**—A major unsolved problem in the treatment of these extensive full-thickness burns is a tendency for small areas to break down late and remain as chronic slow-growing superficial ulcers They often start from abraded blisters and small raw areas and occur most commonly on the leg when early walking has been allowed without support to the grafted areas, they are not particularly common in flexures No specific organism can be considered responsible, nor has mycotic infection been demonstrated

The cases that are most subject to them and which are most resistant to treatment are those



which have not been healed promptly by early skin grafts, or where grafts have been applied to a surface of hypertrophic granulations or have been placed too far apart

This is the main reason for early and intensive grafting of all raw areas and regrafting of any residual area that is not certain to be healed within 10 days

Patch grafts will sometimes take on these areas after a period of intensive ward and theatre toilets, but if they fail, the raw area and the thick underlying fibrous layer must be totally excised and the fresh bed so prepared can be successfully grafted

**Perichondritis**—This important late complication occurred in 5 per cent of the burns with full-thickness skin loss in this series. It is exquisitely painful and tends to persist until most of the auricular cartilage is destroyed. It is treated by drainage of pus and removal of infected cartilage by curette. Even in cases which respond to one operation there is considerable deformity of the ear on healing, and usually all that is left is a bulbous stump of an ear totally lacking the auricular cartilage

are not subject to it. Acute sulphonamide photosensitivity is a distinct condition and has been seen three times in burns cases. Both these sensitizations are usually temporary

This group of complications emphasizes the need for treating burns in close collaboration with a dermatologist

## RESULTS

Healing times of the 192 cases grafted are shown in *Table IV*. These times are given from the day of grafting rather than the day of burning because of the very variable times at which cases were admitted. The cases are divided into five groups according to size of area grafted, from less than 100 sq cm to over 1000 sq cm

A comparison of the overall average healing times of the different groups shows a striking fact. It is that size of granulating area has little relation to time of healing. Thus the average healing time of all areas under 300 sq cm was 17 days and that of all the areas between 500 and 1000 sq cm was 22 days

*Table IV*—ANALYSIS OF HEALING TIMES IN 192 CASES TREATED BY SKIN-GRAFTS

Table showing average healing times in days from first graft of different areas of full thickness skin loss and the influence of size of grafted area, date of grafting and use of penicillin

Size of area	EFFECT OF GRAFTING WITHIN 5 WEEKS				
	0-99 sq cm Days	100-299 sq cm Days	300-499 sq cm Days	500-999 sq cm Days	1000 sq cm and over Days
First graft within 5 weeks	10 (10 cases)	15 (32 cases)	23 (14 cases)	22 (13 cases)	21 (17 cases)
First graft after 5 weeks	19 (23 cases)	21 (36 cases)	38 (12 cases)	22 (8 cases)	34 (27 cases)*
	EFFECT OF LOCAL USE OF PENICILLIN-SULPHATHIAZOLE POWDER				
	With penicillin	Without penicillin	With penicillin	Without penicillin	With penicillin
With penicillin	16 (16 cases)	15 (39 cases)	25 (13 cases)	16 (12 cases)	30 (30 cases)*
Without penicillin	21 (17 cases)	20 (29 cases)	35 (13 cases)	29 (9 cases)	27 (14 cases)
OVERALL AVERAGE FIGURES					
All cases	18 (13 cases)	17 (68 cases)	29 (26 cases)	22 (21 cases)	29 (44 cases)

\* These groups included 11 cases with full thickness skin loss of 2000 sq cm and over

**Cicatricial Complications**—This note concerns the contractures and hypertrophic scars which are seen in the deeper partial-thickness burns, with destruction of the epidermis and superficial parts of the dermis, after healing has occurred from surviving dermal elements within the area of the burn. Such burns take 3-6 weeks to heal. The scars are then red and hypertrophic with considerable underlying dermal fibrosis and the end-result can be as crippling as the scar of a burn with FTL which has healed by marginal ingrowth and contractions

In sites such as the neck, axilla, and popliteal fossa the scars of dermal burns often cause major persistent disability and are tender, irritable, and tend to crack and ulcerate with minor trauma. This condition has been treated by excision and free sheet grafts. Post-operative X-ray therapy would have been valuable in limiting contraction of the scars. There is probably a role for primary excision of localized dermal burns in these sites with immediate application of free grafts

### Dermatological Complications—

**Pyoderma**—It is quite common for a patient with healed burns to develop a localized or generalized pyoderma, a complication which is resistant to treatment and entails prolonged hospitalization.

**Sun-sensitivity** of healed burnt skin is common in sunny climates and consists in most cases of mild vesiculation. Free grafts of normal unburnt skin

Excluding patients who have lost 2500 sq cm of skin and more, the important thing in healing is not the size of the burnt area, but the resurfacing programme and the time-table to which it is geared

The second principle of fundamental importance in healing raw areas is to graft early. We had long realized this as a clinical impression based on experience of particularly striking cases. Thus a phosphorus burn with loss of 1000 sq cm of thigh skin, whose sloughs were removed on the 18th day, was grafted on the 21st day and completely healed on the 26th. A cylindrical burn of thigh and calf caused by petrol with destruction of 2500 sq cm of skin was admitted on the 15th day, had his sloughs cut off on the 18th day, was grafted on the 20th and 25th days, and was substantially healed by the 35th. In both these cases every patch of graft stuck and grew briskly. The consolidated figures for all cases grafted early confirm this impression, early grafts take best, grow more rapidly, and the raw areas are healed 1-2 weeks sooner.

The table also analyses the effects of penicillin on healing times. The 192 cases fell into two approximately equal groups, those treated without and those treated with local penicillin. The penicillin-treated groups consistently showed a shorter healing time. In assessing these results it is necessary to mention that the two groups were admitted for treatment at approximately the same times after

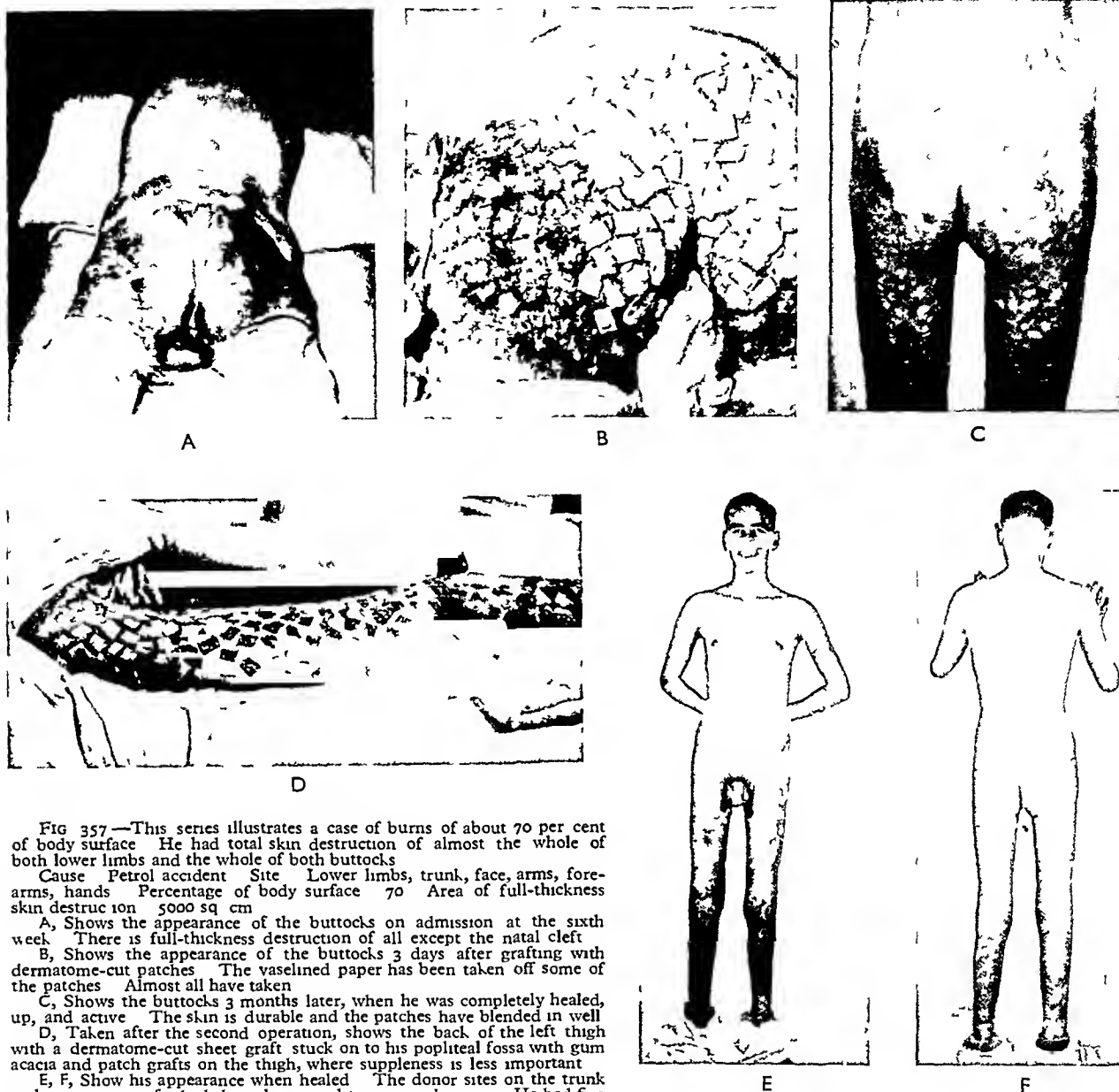


FIG 357—This series illustrates a case of burns of about 70 per cent of body surface. He had total skin destruction of almost the whole of both lower limbs and the whole of both buttocks.

Cause: Petrol accident. Site: Lower limbs, trunk, face, arms, fore-arms, hands. Percentage of body surface: 70. Area of full-thickness skin destruction: 5000 sq cm.

A, Shows the appearance of the buttocks on admission at the sixth week. There is full-thickness destruction of all except the natal cleft.

B, Shows the appearance of the buttocks 3 days after grafting with dermatome-cut patches. The vaselined paper has been taken off some of the patches. Almost all have taken.

C, Shows the buttocks 3 months later, when he was completely healed, up, and active. The skin is durable and the patches have blended in well.

D, Taken after the second operation, shows the back of the left thigh with a dermatome-cut sheet graft stuck on to his popliteal fossa with gum acacia and patch grafts on the thigh, where suppleness is less important.

E, F, Show his appearance when healed. The donor sites on the trunk and arms, some of which have been used twice, can be seen. He had five grafting operations altogether.

His recovery was complicated by persistent diarrhoea and an attack of malaria.

being burnt, but that probably the grafting technique was better in the second group. The effect of penicillin has, of course, been to control infection and not as a direct epithelial stimulant.

**Final Appearance**—The final appearance of a burn healed by patch grafts depends on three factors: thickness of the patch, the closeness of the packing, and the manner in which each particular patient heals.

Thin patches closely packed heal with a smooth, flat surface. In the early stages the appearance is chequered, but within 6–8 weeks the patchwork quality begins to fade and the striæ uniting the patches appear as a faint pink network on a *café au lait* background. The thicker, the bigger, and the more widely spaced are the patches, the more persistently unsightly is the final scarring. Thick

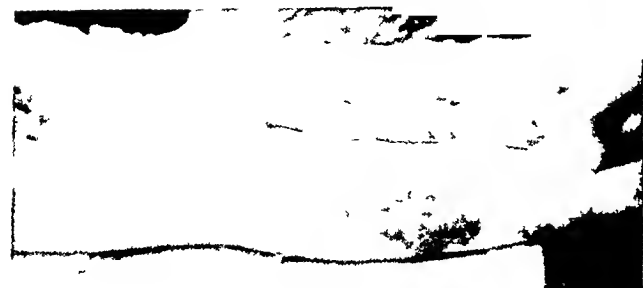
big widely-spaced patches remain as slightly raised white plaques in areas of pink smooth epithelium formed by marginal outgrowth from them.

## DEATHS

Table V shows the cause, percentage of body surface affected, chief depth of burn, area of full-thickness skin loss, primary treatment, day of admission and death, and the cause of death.

These nine deaths give a late mortality for a series of pre-eminent serious burns, in North Africa and Italy, of approximately 1 per cent.

This mortality contrasts with an early mortality of 5 per cent (7 deaths) in the 150 cases in this series whose treatment was undertaken within 24 hours of burning. Nearly 100 of the primary burns were from three naval incidents, and were caused by



A



B



C



D

FIG 358—This series illustrates a case of burns of about 45 per cent of body surface by a petrol cooker accident, which was healed by two patch grafting operations with a 3 day interval during the eighth week.

Cause Petrol accident Site Lower limbs, face, forearms, and hands Percentage of body surface 45 Area of full-thickness skin destruction 3500 sq cm

A, Taken when he was first seen, shows granulating full-thickness skin destruction of about 75 per cent of both lower limbs, his face and hands and arms had healed at this stage. Bilateral tibial crest sequestra are seen and the left one is shown in B.

B, Sequestrum of crest of left tibia, removed at the first grafting operation, as it was found to be loose. Its bed was immediately covered with patch grafts, which all took. The right sequestrum was left, as it was firm, and it separated naturally a month later.

C, D, Show his appearance when healed and ambulatory, 5 weeks later, and show also the four dermatome graft donor sites on his trunk.

This patient was grafted during an attack of acute glomerulonephritis, which started a month before grafting and persisted for a month after. During all this time he had haematuria, blood urea of 50-70 mg/100 cc and blood pressure about 170/110. After the second operation he had a uraemic fit, but his course was otherwise uneventful.

Table V—THE 9 LATE DEATHS IN 800 CONSECUTIVE BURNS

No	CAUSE	BODY AREA	CHIEF DEPTH	TREATMENT	DAY OF ADMIS- SION	DAY OF DEATH	CAUSE OF DEATH AND COMMENT
<b>Part A (The 3 deaths in 192 cases grafted)—</b>							
1	Tank casualty	40 per cent	Full thickness loss 2000 sq cm (approx)	SV G, Patch grafts	9	42	Friedlander pneumonia of blast lung
2	Tank casualty	40 per cent	Full-thickness loss 2000 sq cm (approx)	SV G, Patch grafts	27	40	Prolonged anaesthesia under 2.5 g pentothal. Half raw area healed
3	Air crash	5-10 per cent	Epidermal infective thickness loss	GV tan, 5th full day Gross infection, late Penicillin	38	49	Staph aureus pyemia
<b>Part B (The 6 other late deaths in 800 consecutive serious burns)—</b>							
4	Phosphorus	40 per cent	Full thickness loss and dermal	GV tan, sulphathia- zole	2	8	Agonal Staph aureus in blood early acute liver atrophy
5	Cordite	40 per cent	Epidermal, dermal	SV G, prophylactic and therapeutic peni- cillin	6	21	Prostatic and pulmonary abs- cesses Burns dry and healed
6	Cordite	10-15 per cent	Epidermal	SV G, penicillin	5	11	Thyroid and pulmonary ab- cesses Burns dry and healed
7	Tank casualty	30-35 per cent	2000-3000 sq cm FTL	SV G	8	8	Died a few hours after admis- sion Jaundice ++ Hb 10 per cent
8	Tank casualty	30-35 per cent	2000-3000 sq cm FTL	SV G	8	8	Died a few hours after admis- sion
9	Cordite	40 per cent	Epidermal and dermal	SV G	1	8	Adrenal hemorrhage

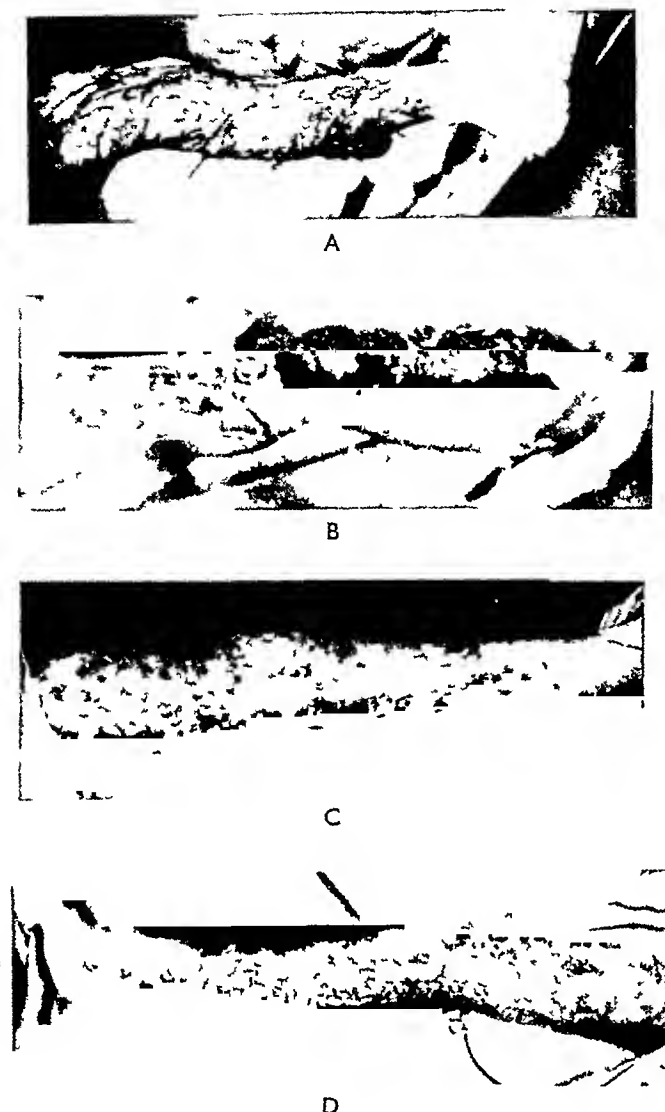


FIG 350—This series shows a case of accidental petrol burns with cylindrical skin destruction from left groin to ankle. He was admitted on the eighteenth day.

Cause Petrol accident Site Both lower limbs, penis, lower part of buttocks, hands Percentage of body surface 30 Area of full-thickness skin destruction 2500 sq cm

A, B, Taken on admission, show large areas of adherent dark sloughs. These were radically excised with scissors and knife. They were riddled with burrowing pus, 1200 patch grafts, cut with a Blair knife from the opposite thigh and both arms, were applied at two operations, 2 and 5 days later respectively.

C, D, Show the appearance 10 days after admission, all the patches have taken and the limb is almost healed.

E, F, Show him at the thirty-eighth day and 20 days after admission, healed and ambulatory.

phosphorus, cordite flash, and superheated steam respectively. These early deaths were in burns which involved 60 per cent, 70 per cent, 80 per cent (2), and 90 per cent (3) of the body surface.

In the cases grafted none of the deaths was primarily due to burns. One was a tank casualty with extensive blast effects in his lung who died of a Friedlander pneumonia on the 42nd day when he was practically healed. The second patient had successfully had half his 2000 sq cm of raw area resurfaced, and had by then regained normal sleep, appetite, pulse, and temperature. At his second operation, which lasted 2½ hours, 25 g pentothal were used and he remained in deep coma with hyperthermia until death 24 hours after operation. Deep post-operative coma and hyperthermia were observed in other burns cases given 1 g and more of pentothal during that summer.

The third death in the grafted series was due to sepsis. The patient died of staphylococcal pyæmia on the 11th day after admission, 49 days after sustaining epidermal burns of the hands, wrists, face, and neck. The burns had been coagulated with gentian violet on the 5th day. On admission on the 38th

day, he was grossly emaciated, had multiple bed-sores, and his burnt areas were gelatinous hypertrophic granulations with profuse *Staph aureus* and hæmolytic streptococcal pus. His pyæmia and death were not inevitable results of his burns, which involved less than 10 per cent of the body surface and were initially superficial. It is thought that the pyæmia and fatal result were caused by late coagulation of an infected burn combined with inadequate nutrition.

On the basis of the cases described here, it is fair to suggest that death is not inevitable with burns up to 70 per cent body surface, with areas of full-thickness skin loss of up to 5000 sq cm, which have thorough general treatment and prompt surgical resurfacing, but these severe deep burns are very prone to grave complicating conditions, which in this series included typhoid, glomerulonephritis, and malaria.

A man can be seriously ill for a week with only 10-20 per cent of his body surface burnt, but he should not die. All cases with 30 per cent of the body burnt are seriously ill for at least 2-3 weeks. When the area involved reaches 50-60 per cent of

the body the odds remain for a month against survival

The four deaths from sepsis in the total series of 800 burns (Nos 3, 4, 5, and 6) occurred in 10 per

30-35 per cent body surface involved fat and muscle for most of their extent and who died a few hours after their admission on the 8th day. The exact cause of death in these cases is not known. Death



A



B

FIG 360—This set illustrates a case of electric burns of trunk and scalp, involving the skull. His trunk was covered by patch grafts in the usual way. The area was infected with hæmolytic streptococci and is one where fixation of the grafts is often unsatisfactory. Three grafting operations were needed.

His scalp burns exposed a bare area of external table of the occipital bone. This was treated by removing the external table with a chisel and immediately applying patch grafts to the diploe. All these grafts took.

Cause Electric Site Back of trunk and scalp Percentage of body surface 15 Area of full thickness skin destruction 1200 sq cm

A, Shows the burns of his back healed after grafting.

B, Shows the appearance of his scalp after healing of the patch grafts applied to the diploe exposed at operation.

cent (2) and 40 per cent (2) burns. They were all staphylococcal pyæmias and must be considered to have been preventable. Two of these staphylococcal

was certainly accelerated by a 200-mile evacuation when the patients were critically ill, but the depth as well as the area of the burn is important in the prognosis for life, and these two cases were probably fatal from the start.

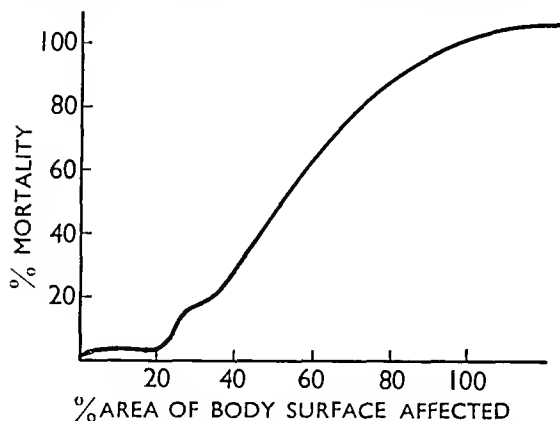


FIG 361—Graph showing relation of percentage of body surface involved plotted against mortality. The mortality is less than 1 per cent below 30 per cent body surface, 10 per cent between 30 per cent and 35 per cent, 20 per cent at 40 per cent body surface, 80 per cent above 60 per cent body surface, and when 80-90 per cent of the body surface was burnt all cases died.

pyæmias had full penicillin, one late penicillin, and the fourth full sulphadiazole. The remaining three fatal burns (Nos 7, 8, and 9) comprised one who had an adrenal hæmorrhage, and two in which

## SUMMARY

The management of 800 serious burns and the resurfacing problems of 192 of these during the healing and rehabilitation phases are described.

The history, recognition, and course of burns destroying the full thickness of the skin are detailed, and the reasons are given why it is important to assess the depth of burn early.

The preparation for grafting and methods of cutting and applying skin to extensive and to special areas are described, and the importance of carrying out a rapid resurfacing time-table for these cases is stressed.

The local complications of burns, infective, cicatricial, and dermatological, are discussed.

Results of 192 cases are given which show that all areas up to 2500 sq cm should be healed in 20-35 days from being burnt, areas of 2500-5000 sq cm have to be resurfaced at a slower rate and take 40-60 days.

The results recorded demonstrate the beneficial effects of early removal of sloughs, and the employment of penicillin, on the success of grafts and on healing times.

The early and late mortalities in 800 serious burns are given, and the causes of the 1 per cent late mortality in this series is discussed.

It is a pleasure to express our thanks to Major Roche and Captain Clynick for their expert anaesthesia, which was available for most of the cases, to Captain Grossmann, who treated many of the cases

completely, and who had the ward care of most of them, to L/Cpl Gale for his most expert dressings and assiduous care of patients in the saline bath and the theatre staff—Corporal Cordery, Corporal Parker, and Private Farwell, who, under Sister P Clutton, consistently provided theatre services of the highest standard by unremitting dreary work

## INJURIES TO THE PANCREAS AND THEIR SURGICAL TREATMENT\*

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THE pancreas by virtue of its deep situation is well protected from the effects of the various injuries and insults which may be inflicted upon the abdomen and which form part of the hazards of everyday life. It is not surprising, therefore, to find that injuries to the pancreas are uncommon and few surgeons have an extensive experience in dealing with them. As might be expected, too, most injuries of the pancreas are associated with extensive injuries to other abdominal viscera, the liver, spleen, and stomach being most commonly involved, and are thus often beyond the reach of surgical aid. However, the close apposition of the body of the pancreas to the unyielding body of the first lumbar vertebra makes it possible for the pancreas to be crushed or ruptured or torn across in crush injuries of the upper abdomen, and the more so if the trauma is a very sudden one which produces its effects before the abdominal musculature has time to guard against the blow. In such cases the pancreas may be injured apart from any other viscus and Garre in 1905 was able to find 8 cases in the literature in which the pancreas was the only organ to be uninjured, including one personal case of rupture of the pancreas which he was able to cure by suturing. Most collected series of cases of pancreatic injury have included a number in which the injury has been produced by bullets and other missiles or by knife or bayonet, but it is not the purpose of this paper to consider wounds of the pancreas which may result from warfare, but rather those resulting as suggested above, from crush injuries of the abdomen. The trauma which may give rise to such injuries may be surprisingly slight and is often not sufficient to produce any wounding or bruising of the parietes, and this is probably a reflection of the flaccid condition of the abdominal musculature at the time of the accident which in itself made the injury possible. Such an injury may vary from complete rupture of the gland to simple bruising, and naturally the condition of the patient will vary accordingly. In the severe injuries with complete rupture there will be no doubt in the mind of the surgeon that laparotomy will be required, although often no exact pre-operative diagnosis can be made. In this connexion attention may be drawn to the importance of left

shoulder-tip pain in injuries to the pancreas which produce effusions into the lesser sac, a case in which this formed an important feature was reported by A L d'Abreu in 1935, and is among the series of cases reported later in this paper.

There remains, however, a number of cases in which no lesion of the pancreas is suspected at the time and in which the condition of the patients is such that they escape immediate laparotomy only to return at a later date with symptoms which are directly referable to the original injury. The following are given as typical case histories of such patients, who form a most fascinating and important group of pancreatic injuries—

*Case 1*—L H, aged 16, while at work on Monday morning, Jan 12, 1941, in the colliery, was knocked down by a runaway coal truck which struck him in the upper abdomen on the left side. He experienced great pain at the time and was sent home by ambulance and put to bed. He was seen by his doctor, who kept him in bed and ordered Epsom salts. He vomited greenish material on Monday and Tuesday and the pain in his abdomen remained, being aggravated by deep breathing. On Thursday he was admitted to the Cardiff Royal Infirmary as an emergency under the care of the Surgical Unit. On examination he was found to be pale, pulse 102, T 100°. He was complaining of upper abdominal pain. There was a slight abrasion on the abdomen above and to the left of the umbilicus, tenderness and some muscle guarding in the left hypochondrium. Urine was normal. He rapidly improved on expectant treatment and was discharged completely symptom-free on Jan 23, after 11 days in hospital.

He was re-admitted again on Feb 11, 1941. He said that since returning home he had had two attacks of upper abdominal pain associated with vomiting, each lasting several days, and that a month after his original injury he had noticed for the first time a swelling in the upper abdomen, for which his doctor had advised his re-admission. On examination, he was found to have a tense swelling in the left hypochondrium, the outline of which is shown in the photograph (Fig 362). A barium meal showed a large filling defect in the stomach consistent with an extragastric mass. Laparotomy was carried out on Feb 18, 1941, and a pseudo-pancreatic cyst found presenting between the stomach and colon. It was found to be too inaccessible for easy marsupialization and was accordingly aspirated and the abdomen closed with a drainage tube down to the site of aspiration. The wound healed without drainage and the patient was discharged on March 17, 1941.

He was re-admitted for the third time on Oct 16, 1941, gave a history of attacks of abdominal pain which

\* Being a Hunterian Lecture delivered at the Royal College of Surgeons, May 4, 1945

doubled him up and which occurred about once a fortnight, lasting a few hours. On examination, he was found to have a large swelling in the left hypochondrium, rather bigger than at the previous admission. Laparotomy performed Oct 30, 1941, cyst the size of a football, 2½ pints of cloudy fluid aspirated, marsupialized and drained. Discharged Nov 22, 1941—healed.

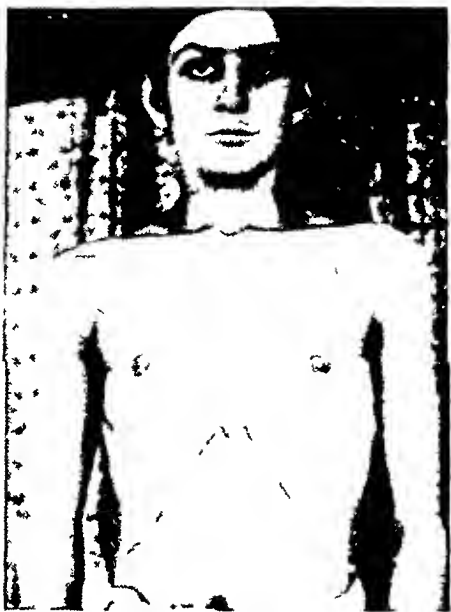


FIG 362—Photograph showing outline of swelling in left hypochondrium

He has been admitted once since, in 1943, under the care of the physicians with catarrhal jaundice—otherwise he has remained well.

*Case 2*—G H C, aged 37, was admitted to Llandough Hospital on Nov 5, 1942, under the care of Mr D J Harries, having been thrown out of a lorry and sustained injuries to chest and abdomen. Pain and tenderness were present in left hypochondrium, but no rigidity. Several attacks of pain and vomiting and abdominal distension while in hospital. Discharged from hospital Dec 21. Re-admitted Feb 10, 1943, with a large mass in the upper abdomen, which was found on laparotomy to be a large pseudo-pancreatic cyst. It was marsupialized and drained.

These cases will suffice to illustrate the way in which trauma may produce late results in the form of a cyst or pseudo-cyst of the pancreas. It must not be supposed that such conditions are common; indeed, a careful search through the Cardiff Royal Infirmary records for the last fifteen years reveals only 2 cases out of about 75,000 total in-patients treated in the Infirmary during the same period, and this accords with the experience of others. Judd, Mattson, and Mahorner (1931), in one of the largest series of collected cases of pancreatic cyst, report on 88 cases from the Mayo Clinic out of 723,397 surgical patients admitted during the same period. When it is remembered that less than 25 per cent of these 88 were cysts due to trauma, the incidence of the condition is seen to be 1 in 40,000 and its rarity will be appreciated.

It is very noticeable in all the reported series that cysts following on inflammatory conditions of the

pancreas are very much commoner in women than in men, being commonly associated with chronic cholecystitis and cholelithiasis, while those resulting from trauma occur more commonly in males, in association with the greater hazards of their occupations, all 3 cases in this paper were in males. The time interval between the infliction of the trauma and the appearance of the cyst is very variable, from a few days to over a year, but many cases seem to present within a month or six weeks of the injury, which may be taken as typical. The pathological processes which lead to the formation of a cyst in such typical cases would appear to be as follows. Bruising of the pancreas produces a hæmatoma beneath the capsule. Damaged pancreatic cells release their ferments into this, fat necrosis is often seen in immediate operations upon pancreatic injuries. The trypsin in the juice, while normally inactive as secreted, becomes activated by contact with damaged and devitalized tissues and digests the clot, thus giving rise to further bleeding from the thin-walled pancreatic vessels. This process is repeated and the cyst enlarges as a result of repeated hæmorrhages. The digestion may go on until the pancreatic duct is involved, when the size of the cyst will be rapidly increased by the admixture of pancreatic juice. No doubt there are many variations of this process and the cysts of rapid onset are probably due to rupture of the capsule of the pancreas, frank hæmorrhage, and escape of pancreatic fluid into the lesser sac of the peritoneum. However, the above seems to be the ordinary mechanism, and the growth of the cyst by means of repeated hæmorrhages is stressed, as it may well form a basis for the earlier recognition of the condition. It would appear that the critical period for the recurrence of hæmorrhage into a cyst is from 10 to 14 days after injury, and from a careful examination of the case records it is evident that the hæmorrhage when it occurs frequently produces an attack of epigastric pain and vomiting in the patient, associated with varying degrees of shock. Both the case histories quoted give evidence of this. The occurrence of such attacks, therefore, in a patient who appears otherwise to be recovering satisfactorily from upper abdominal trauma should lead the surgeon to suspect the onset of a pseudo-pancreatic cyst.

In the established case there should seldom be any difficulty in making the diagnosis, as the characteristic swelling in the left hypochondrium may be easily seen as well as felt.

Pancreatic cysts may extend in various directions, above the stomach, between the stomach and the colon, or downwards behind the colon into the pelvis, but by far the commonest is between the stomach and colon, when it will produce the classical appearance of swelling in the epigastrium or left hypochondrium.

Of the accessory methods which we have for confirming the clinical diagnosis, the most consistently valuable is the barium meal radiographic examination, when a variety of deformations of the stomach or duodenum may be shown produced by the pressure of the large extragastric mass. Diagnosis having been established, it remains to consider the appropriate surgical treatment. In 1862 Le Dentu punctured a cyst of the pancreas and drained it under



the impression that it was a cyst of the liver When the patient died of peritonitis he somewhat gloomily wrote —

"Cysts of the pancreas should be relegated to the list of those affections where the healing art is impotent"

While we should agree with him in his condemnation of needling either as a method of diagnosis or treatment, surgery has advanced since his day and now holds out three possible and satisfactory forms of treatment for the condition The three types of operation which have been advocated and applied are excision, marsupialization and drainage, and primary anastomosis between the cyst and the stomach or small intestine Of the first it may be said that, while the most radical, it is seldom practicable for technical reasons The second method has

pancreatic fistula, which leads me on to this further sequel to pancreatic trauma which may confront the surgeon, and which has its own peculiar and fascinating problems

Most of the pancreatic fistulæ which have been recorded in the literature have followed the drainage of pancreatic cysts and it may be inferred that if pancreatic cysts are of rare occurrence, pancreatic fistulæ will be even rarer, and this is borne out in fact However, pancreatic fistulæ may follow on immediate operations for pancreatic trauma and from other operations in which the pancreas may be damaged, notably gastrectomy, and, of course, from any operation upon the pancreas itself It is noticeable in this connexion that now that extensive operations upon the pancreas are coming within the field of surgery the number of pancreatic fistulæ

Table I—REPORT ON 7 CASES OF PSEUDO-PANCREATIC CYST

CASE	AGE	SEX	AETIOLOGY	DURATION OF ONSET	TREATMENT	RESULT
L S	16	M	Crush injury to abdomen	1 month	Aspiration-recurrence Marsupialization and drainage	Cured
L L	50	F	Subacute pancreatitis	1 month	Cyst anastomosed with stomach over a tube	Cured
G H C	37	M	Blow on abdomen	3 months	Marsupialization and drainage	Died
F B	57	M	? Carcinoma of pancreas	18 months	Marsupialization and drainage Implantation of resulting fistula into stomach, 5 months later	Died 1 year from generalized carcinomatosis of undetermined origin
C D	69	M	Acute pancreatitis	5 days	Marsupialization and drainage	Cured
B G	7	F	Acute pancreatitis	5 days	Evacuation of large blood-clot in lesser sac, abdomen closed	Cured
A W	13	M	Blow on abdomen	1 month	Marsupialization and drainage	Cured

stood the test of time and experience and probably represents the standard procedure at the present day It has the merits of being easy and of universal application and in fully 80 per cent of cases it produces a rapid cure of the condition Against this may be set the fact that recurrences are by no means unknown, and in some cases where there is major damage to the pancreatic duct or ducts the drainage of the cyst may be followed by the development of a troublesome and intractable pancreatic fistula, although in most cases the fistula will close spontaneously in course of time The third method is of more recent origin and has been introduced with a view to overcoming the objections which have been advanced above to the method of treatment by marsupialization and drainage It has not yet got the weight of experience behind it that marsupialization and drainage have, but so far as it has been tried it is probably the most satisfactory line of treatment which we have to date Of the 7 cases reported in this paper 5 were treated by marsupialization, 1 by evacuation of the cyst and closure of the abdomen, and 1 by anastomosis with the stomach over a rubber tube No more will be said at this stage as it is our purpose to return to a further discussion of this point later in the paper Table I gives a summary of the 7 cases

It will be noticed that in one of these cases drainage was followed by the development of a

being reported in the literature is steadily rising, and this in itself would be adequate reason for discussing so rare a condition, for it may be that in the future it may become a far more common complication of surgery than it is at present For myself I can say that the study of the one case which I have had under my care has proved most stimulating and has led me into the byways of physiology and biochemistry which are unfamiliar haunts for the surgeon and which have provided a welcome excursion for the mind which in these days of specialization too easily resigns itself to the familiar scene and the well-trodden path It will perhaps be appropriate at this stage to recount the story of the case of pancreatic fistula which it has been my fortunate lot to observe and to pass from this to a discussion of the various problems which these cases present, and the treatment appropriate to the condition

Case 3—On the afternoon of Feb. 24, 1944, there was admitted under my care at the Whitchurch Emergency Hospital a small boy aged 9 His story was that shortly after lunch that day, whilst engaged with helping with the milk round, he had been unfortunate enough to meet with an accident He had been sitting on the back of the van, which started suddenly, throwing him off on to the ground, and which then added insult to injury by backing, so that one of the rear wheels ran over his upper abdomen The child had vomited almost immediately and had been taken home in the van, vomiting again on his arrival He was seen by his doctor,

who sent him straight into hospital, where he arrived two hours after the accident

When I saw him the same afternoon he was sitting up in bed calmly studying a coloured comic and he did not seem much distressed and was able to give a clear account of the accident. His temperature was 97° and his pulse 80. There was a slight abrasion on the abdomen just above the left anterior superior spine, but there was little tenderness and no rigidity. He was accordingly treated conservatively and put on a half-hourly pulse record and food and fluids withheld. His pulse rose slowly during the night and was 104 when seen in the morning, when he vomited again, the vomit being projectile in character, and was observed to have visible peristalsis in the region of the umbilicus. Laparotomy was, therefore, carried out immediately.

On opening the peritoneal cavity there was a considerable escape of dark blood and it was immediately seen that there was a rupture of the liver extending from the inferior edge down into the portal fissure and almost completely avulsing the quadrate lobe, which was accordingly removed. The lesser omentum was torn and there was also seen to be bruising and hæmorrhage into the body of the pancreas and several well-marked areas of fat necrosis in the neighbourhood. A routine exploration of the intestinal tract produced the surprising finding of an entero-enteric intussusception about 6 in. long at about the mid-point of the small intestine. This was easily reduced and no cause for it was seen or felt. There was no other injury in the abdomen. The rent in the liver was sutured and the abdomen closed with a rubber drainage tube down to the damaged pancreas.



FIG 363—Drainage of fistula through a catheter leading into a bottle

The drainage tube was removed on the second day, but on the fourth day a clear, watery discharge appeared at the site of the tube and rapidly increased in quantity until the dressings were constantly wet through. A specimen of the fluid showed it to be pancreatic juice with a pH of 9 and the diastase estimation gave a value of 2000 Wohlgemuth units. Some superficial excoriation of the abdominal wall appeared in the next few days, but at no time was there any serious digestion of the abdominal wall and even the slight excoriation which was present was extremely ephemeral, sometimes being present in the morning, but completely healed by the same evening. Within a few days it was possible to insert a catheter into the fistula and drain the fluid into a small bottle (Fig 363). Following the development of the fistula the boy's condition steadily deteriorated. He rapidly developed the features of extreme dehydration and this was aggravated by attacks of vomiting, which were often projectile and violent in character. His fluid and salt balance was maintained by rectal salines to supplement the fluid by mouth. Loss of weight was progressive and severe and this was accompanied by anorexia and marked asthenia and he was soon reduced

to little more than a living skeleton. Curious mental changes also appeared at this time manifested by several attacks in which the patient would suddenly rouse himself from his weak, almost stuporose condition, to become transformed momentarily into a wild animal at bay. In these attacks the boy would sit up in bed with bared teeth, and convulsively clenched hands, ready to bite or scratch anyone who approached, and emitting, from time to time, wild and piercing screams. He would pass rapidly from this state back into his stuporose condition and had no memory of the attacks afterwards.

About a fortnight after the onset of the fistula the patient, who had been better for two days, slipped into the semi-comatose condition which has been so well described by Whipple and others under the term "pancreatic asthenia". In this condition the pulse was almost imperceptible and the breathing so shallow that the boy had every appearance of death. An intravenous saline was at once started, and within a very few minutes the boy revived. From this time progress was slow but steady, although the extreme wasting remained for some time. The fistula closed spontaneously in two months, and following this the patient rapidly put on weight and was discharged from hospital on May 25. He has remained well since this time.

The above clinical record raises many problems in connexion with pancreatic fistulae which have engaged the attention of a number of investigators and which may be summarized as follows—

- 1 The volume and control of pancreatic secretion
- 2 The cause of death in fatal cases and of pancreatic asthenia in less severe ones
- 3 The degree of importance of the external secretion of the pancreas to normal digestion
- 4 The enzymatic activity of pancreatic secretion
- 5 The treatment of pancreatic fistulae

**1 The Volume and Control of Pancreatic Secretion**—It is generally accepted that the pancreatic secretion is under the control of both nervous and humoral influences. The humoral control is effected by means of secretin which is liberated from the duodenum in response to the discharge of the acid contents of the stomach into it. The secretin thus thrown into the blood-stream stimulates the pancreas to produce a large volume of secretion rich in sodium bicarbonate. Stimulation of the vagus on the other hand, has a much smaller effect on the volume secreted, but produces a fluid which is rich in digestive ferments. Thus it will be seen that the volume and alkalinity of the secretion are largely under humoral control while the digestive activity is under nervous control. The secretin mechanism contains within it the elements of an automatic regulator or cut out, for the alkaline secretion poured out in response to the acid chyme entering the duodenum rapidly brings about its neutralization and consequently the cessation of the stimulus. It is quite clear that in cases of fistula this automatic control is rendered inoperative. The pancreas responds to the secretin stimulus, but the resultant flow of fluid does not reach the duodenum. It is for this reason that I believe that all inferences as to the normal output of external pancreatic secretion, based upon data derived from cases of fistula, are probably erroneous and tend to be much too large. Probably they represent the maximum output of the gland, working at full pressure in response to

over-intense and over-prolonged secretin stimulation. However this may be, the volume of fluid produced in fistula cases is certainly very impressive and values up to 2000 c c have been recorded, the

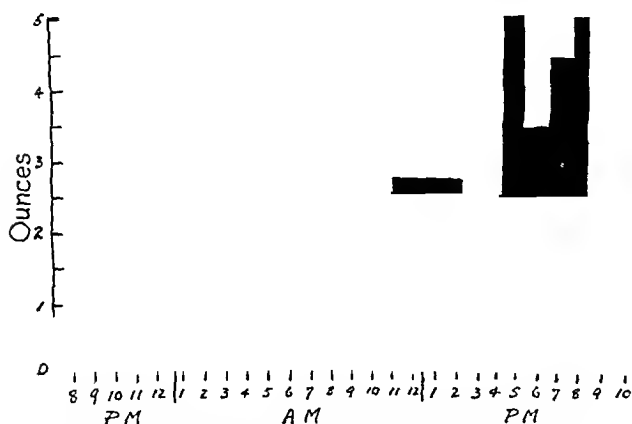


FIG. 364.—Record of output of pancreatic fistula for 24 hours. The increase in secretion in response to food is well shown.

case I have reported produced as much as 46 oz. in the 24 hours (Fig. 364). The secretion in pancreatic fistulae is also continuous, going on by night and day, but again I think it would be wrong to assume that this is necessarily the case in the normal individual for the reason given above. In this connexion attention may be drawn to the conflicting results obtained by vagal stimulation and vagotonic drugs. Many observers have reported a drop in the volume of secretion following such measures. Apart from the fact that such vagotonic drugs usually stimulate gastric motility and hydrochloric acid output, and hence might be expected secondarily to produce an increase in volume of pancreatic secretion via the secretin mechanism, the result should not surprise us. What is more significant is the effect of such drugs as pilocarpine, etc., on the enzymatic activity of the fluid, and little or no work in the human has been done on this problem. The absence of evidence for psychic secretion reported by several workers is also to my mind inconclusive, as the only index of secretion commonly used is the volume.

**2 The Cause of Death in Fatal Cases and of Pancreatic Asthenia in Less Severe Cases**—It was shown experimentally by McCaughan (1929) more than 15 years ago that complete pancreatic fistulae in dogs were invariably fatal in from 5–8 days. If death did not occur in this time after the experimental establishment of a fistula it was invariably found at autopsy that the fistula was not complete and that some part of the pancreatic secretion was finding its way into the duodenum. The cause of death in fatal cases was thought to be mainly the profound anhydræmia resulting from the fistula. The blood-chemistry was found to be little altered apart from a slight reduction in the chlorides and a terminal rise in non-protein nitrogen. There was no constant variation in the carbon-dioxide-combining power of the plasma. They further established that intravenous administration of saline prolonged life and maintained normal blood-chemistry and that administration of whole pancreatic juice by mouth restored even moribund animals to health. In dogs in which only a partial fistula was

induced there was no constant clinical picture produced, some of the dogs suffering from dehydration and loss of weight and others remaining in comparatively good health. All this conforms fairly closely to the findings in human cases of pancreatic fistula. It is rare for a human pancreatic fistula to be complete and thus fortunately its fatal effects are seldom observed, but there is no doubt that they will occur and would have done so in the case cited apart from the institution of vigorous treatment. However, the cause of death in such cases is not yet sufficiently clear and is almost certainly due to a number of contributory causes. The dehydration is an obvious factor. Human pancreatic fistulae may secrete up to 2000 c c (3½ pints) of fluid in a day, which represents a very substantial fluid loss. In addition to this there is the fluid lost in the vomiting which is such a common concomitant of the condition. This dehydration is rapidly reflected in the sunken eyes and inelastic skin of the sufferer. Then, too, pancreatic fluid contains an appreciable quantity of protein, albumin and globulin, and this mounts up in the large volume secreted to produce a serious drain on the plasma proteins. This is to some extent compensated for by the anhydræmia and reduction of blood-volume, so that the reading obtained may not be low unless it is interpreted in relation to the concentration of the blood (Table II).

Table II—Case 3 REPORT ON BLOOD EXAMINATION (APRIL 10, 1944)

Titration for non-ionized alkali in the serum, gives similar results to those of normal blood			
Total proteins	8.25 g	per cent	
Albumin	6.0 g	„	„
Globulin	2.25 g	„	„

Pancreatic fluid also is a markedly alkaline secretion—the pH of the specimen recorded was 9, this alkalinity is due to the high sodium bicarbonate content, and it might be thought that such a constant drain in alkali would produce a significant acidosis. While there is no doubt that it does to some extent do so, the effect should not be over-estimated. In the first place it is to some extent balanced by the frequent concomitant vomiting, and also there is good evidence to show that much of the bicarbonate is produced locally in the pancreas as a product of the metabolism of its cells and is not derived from the blood. This is in keeping with the surprisingly slight changes in blood-chemistry which have been repeatedly reported even in patients who were gravely ill. The finding has been succinctly and wittily summarized by Capt J M Miller and Major T B Wiper (1944) in a recent excellent paper. When reporting a serious case under their care they state “He was in vibrant health in the laboratory, but practically dead in the ward.”

However, although the blood-chemistry changes are slight and may be masked by the concentration of the blood, that is not to say that such changes which are present are not very important. Indeed, the writers referred to above draw attention to the similarity between the condition of pancreatic asthenia and the more extreme forms of Addison's disease and other states in which the blood-sodium is significantly lowered. They noted a fall in plasma-sodium in one of their cases from a normal of 142 m Eq/L to 113.3 m Eq/L, which is well below the

level regarded as diagnostic of Addison's disease. They also point out that reduction of sodium concentration is accompanied by a secondary loss of water, thus increasing the dehydration and enhancing the hæmoconcentration, elevation of blood-proteins, and finally non-protein nitrogen. The resemblance between Addison's disease and the victim of a severe pancreatic fistula is certainly striking, and it is probable that the sodium loss is an important factor in the production of the symptom complex. This discussion of blood-chemistry may seem to be unduly academic, but at least it has an important practical significance as it emphasizes the importance of maintaining the fluid and sodium reserves of the body in all such cases. The dramatic effect of intravenous saline in the patient I have described had to be seen to be appreciated. It is unnecessary to give sodium bicarbonate, as the body is able to supply adequate quantities of the bicarbonate ion as a by-product of its metabolic activities, but it could well be administered as an alternative to saline if vomiting is not present and there is a risk of chloride retention and resultant œdema. The value of whole pancreatic fluid by mouth could not be tested in my case as the patient was not sufficiently co-operative, but many workers have reported very favourably upon the effect of its administration.

While there is no doubt that the main factors contributing to the mortality and morbidity of pancreatic fistulæ are the anhydræmia and blood changes outlined above, there remains an uneasy feeling that this is not perhaps the whole story. It is difficult to understand, for example, why cases with a partial fistula should so often show little or no impairment of health even though the total fluid loss may approach or even surpass that from a total fistula. It raises in one's mind inevitably the question as to whether the external secretion of the pancreas does not supply some factor vital to the well-being of the body. The answer would appear to be conclusively in the negative, for it is known that total extirpation of the pancreas in man is not incompatible with life and even with health and may not even be accompanied by any disorder in the digestive processes. Possibly there may be some individual variation in this and clearly more work is needed on human pancreatic physiology to establish the point.

**3 The Degree of Importance of the External Secretions of the Pancreas to Normal Digestion**—It has just been mentioned that the pancreas has been successfully extirpated in the human without impairment of digestion, and it may well be asked whether the external secretion is of any vital importance in the digestive processes. The occurrence of fatty diarrhœa in cases of pancreatic fistula and other pancreatic diseases is quite inconstant and apparently quite capricious, being unrelated to the severity of the condition (some cases of partial fistula have severe steatorrhœa, while other cases of total fistula have no such symptoms). Probably in most people the succus entericus together with the bile is quite capable of carrying on the digestive processes to completion if the pancreatic juice is wanting, and we have but another example of the prodigality with which the body is supplied with alternative mechanisms to take the place of any which may be temporarily or permanently put out of action. No

doubt, however, there are some individuals who are not thus able to compensate for the loss of pancreatic secretion, and in these the withdrawal of this fluid represents an irreparable loss resulting in serious digestive impairment (*Table III*).

*Table III—Case 3 REPORT ON FÆCAL FAT*

		March 25, 1944	
Total Fat	24	per cent	by weight of dried faeces
	55	per cent	of the total fat is split
45	"	"	" " " " " " unsplit
		April 10, 1944	
Total Fat	6	per cent	by weight of dried faeces
	67	per cent	of the fat is split
33	"	"	" " " " " " unsplit

This leads me to the fourth question concerning pancreatic fistulæ, viz, the enzymatic activity of pancreatic fluid.

**4 The Enzymatic Activity of Pancreatic Secretion**—It is well known that the pancreas secretes three ferments, diastase or amylase, lipase, and trypsin, which act respectively upon carbohydrates, fat, and proteins. With regard to the first, it is constantly present in pancreatic juice, and indeed can hardly be said to be diagnostic of pancreatic fluid as it occurs in fair quantity, for example, in ascitic fluid. Lipase has also been reported present in most of the cases of pancreatic cyst fluid and fistula fluid in which it has been sought. The quantity of these two enzymes present is very variable from case to case and from day to day, e.g., in the personal case the diastatic index was 2000 Wohlgemuth units one day and only 200 units a few days later.

The main interest, however, is focused on the trypsin and the proteolytic activity of pancreatic juice. It must surely be a matter of comment in studying the literature concerning pancreatic fistulæ to find how variable have been people's experiences with regard to the proteolytic activity of fistula juice as evidenced by its tendency to produce digestion of the tissues of the abdominal wall. In some of the reported cases this has been a major complication, while others have remarked on its complete absence. In my own case it was never a problem and comment has already been made on its ephemeral character. The traditional explanation of these facts is, of course, that trypsin is secreted by the pancreas in an inactive form which is activated by a specific enzyme, enterokinase, in the duodenum, and in clinical support of this is adduced the fact that duodenal fistulæ are always accompanied by severe digestion of the abdominal wall. This would, of course, account for the absence of digestion in cases of pancreatic fistulæ, but on the other hand would not explain why some pancreatic fistulæ are accompanied by pronounced proteolytic activity. In order to account for this fact it must be presumed that other things besides enterokinase can bring about the activation of trypsinogen, or trypsin plus protein inhibitor as it is now generally believed to be. Many things have been claimed to be effective in such activation and among the list are calcium chloride, exposure to air, the presence of bacteria, bile, and bile-salts, etc. It is possible that all these may be effective at various times in splitting up the trypsin inhibitor complex, but that they are not always effective is shown in our own case. In one specimen which was kept for 24 hours prior to the assay

and which was found by culture to contain *Str pyogenes*, *Str viridans*, and *Ps pyocyaneus*, no direct tryptic activity could be found, but it was present after activation by calcium chloride (Table IV)

Table IV—Ronald Cokeley ANALYSIS OF PANCREATIC FISTULA FLUID (MAY, 1944)

Full investigation of Pancreatic Fluid	
<i>Pancreatic juice</i>	
Total solids,	1.35 per cent
Inorganic ash,	0.67 per cent
Organic matter,	0.68 per cent (by difference)
Calcium,	2.2 mg per cent
<i>Enzymes</i>	
Diastase—200 Wolgemuth units/c c	
Lipase, B P assay—	8 c c N/1 per cent
Trypsin, Martindale assay	No activity
Activated with 1/10 vol 4.5 per cent CaCl =	
2.7 c c N/1 per cent	
Trypsin inhibitor—100 mg per cent trypsin	
neutralized	
<i>Bacteriology</i>	
<i>Str viridans</i> , <i>Str pyogenes</i> , <i>Ps pyocyaneus</i>	

The action of calcium chloride in this respect deserves comment, I think, in view of the fact that the same pancreatic juice was found to contain 2.2 mg of calcium, a figure which corresponds closely with that cited by other authors including the recent investigation by Capt J M Miller and Major T B Wiper. These authors draw particular attention to the calcium content of pancreatic juice as constituting a little recognized phase of calcium metabolism in which diffusible calcium from the blood-stream is constantly being discharged into the duodenum. They make the point that this must be ionizable calcium as only this fraction of the calcium of the blood is able to diffuse into extracellular fluid. However, it would not seem that this is necessarily the case, and the very fact that it does not produce activation of the trypsin is in favour of its being protein bound. The finding that bile-salts are effective in activating trypsinogen is, I think, most suggestive, and indeed it makes one wonder whether this is not the normal mechanism of activation. Intermittent regurgitation of bile into a pancreatic fistula would in this case account for the presence or absence of tryptic activity in fistula fluid from day to day. That bile-salts do, in fact, activate the trypsinogen of normal blood-plasma has been confirmed for me by Miss B Still, to whom I am indebted for all the biochemical work on the case presented. Once again this may seem to be an academic discussion unrelated to surgical practice, but a clearer understanding of the mechanism involved in trypsinogen activation may well prove a help in dealing with other diseases of the pancreas.

##### 5 The Treatment of Pancreatic Fistulae—

We turn now, finally, to the treatment of pancreatic fistulae. It should be said at the outset that fully 80 per cent of such fistulae close spontaneously in due course, and such closure has been noted even up to a year after the fistula has been established. Treatment in the first instance should, therefore, be conservative and should be directed towards (1) The restoration and maintenance of fluid requirements and normal blood-chemistry (2) The protection of the wound when digestive activity is a feature of the condition (3) Diminution in the volume of the secretion to encourage closure. The first of these has already been adequately dealt with. The second, as has been mentioned, is often no problem at all, but if digestion of the wound is troublesome

probably the best method of treatment is that devised by Caryl Potter (1929) for the treatment of duodenal fistulae. This is based on the fact that trypsin is only active in an alkaline medium, and consists in irrigating the wound with a continuous drip of N/10 hydrochloric acid and dressing it with gauze soaked in 10 per cent Witte's peptone to absorb any tryptic activity which may still be left. Less severe cases can be satisfactorily handled by protection of the skin by liberal applications of vaseline or aluminium paste.

The third objective of conservative treatment—namely, to diminish secretion in order to favour closure of the fistula—may be conveniently discussed under the headings (a) Diet, (b) Drugs, (c) Other measures. Since the volume of the secretion is largely governed by the secretin mechanism, which is in turn dependent upon the motility of the stomach and the acidity of its contents, any measures which will lessen these might be expected to bring about a reduction in the volume of secretion.

*a Diet*—As long ago as 1907, as a result of extensive investigations, Wohlgemuth instituted his dietary regimen for pancreatic fistulae and this has remained the standard since his day. His method was briefly to give a high-fat, low-carbohydrate diet together with plentiful doses of sodium bicarbonate and atropine, all of which measures are designed to diminish gastric acidity and motility. Many have reported favourably on this regime, but more recent and accurate measurements in the human have cast some doubt on its effectiveness. Accurate observations on the effect of various diets and drugs on the secretion of human pancreatic fistulae have been made recently by McCaughan and Purcell (1941) and others, and these have demonstrated that a high-fat meal does not show up particularly favourably in comparison with other diets in effect on the volume of pancreatic secretion. Sodium bicarbonate by mouth in the usual doses also has but little effect. It must be remembered that the effect of sodium bicarbonate upon the stomach is to stimulate the production of more acid, and probably very massive doses are required to overcome this effect. Probably other alkalis such as aluminium hydroxide would have a more beneficial effect, but they do not seem to have been tried. It is quite certain that sodium bicarbonate direct into the duodenum through a duodenal tube markedly decreases the volume of secretion and that dilute hydrochloric acid equally dramatically increases it.

*b Drugs*—With regard to drugs, it would be tedious to enumerate the very large number of drugs which have been tested experimentally. Suffice it to say that ephedrine appears to be the most satisfactory for clinical use. There are other drugs, as for example physostigmin, which have a greater effect in diminishing pancreatic secretion, but they all have unpleasant side reactions of one sort or another which make them undesirable for clinical use.

*c Other Measures*—Some writers have reported favourably on the effect of deep X-ray therapy in diminishing pancreatic secretion and producing closure of fistulae, but the consensus of opinion amongst most recent writers who have tried it is that it has little or no effect, and the same may be said for the use of sclerosing fluids injected into the

fistula One case reported here had a trial of sodium morrhuate injections without effect. If the fistula does not close within a reasonable period, even with the use of the above measures, surgical treatment should be undertaken. In my judgement surgery should not be considered for at least six months if the patient's health is not being impaired by the fistula, as many fistulae have closed after several months. If surgery is deemed advisable the fistula may be dissected out and implanted into an adjacent viscus, the stomach, gall-bladder, and jejunum have all been used for this purpose. Of these the stomach has found most favour and has much to commend it because of its accessibility and the fact that the tryptic activity of the juice which might digest the suture line is immediately destroyed by contact with the acid secretion of the stomach. No untoward effects upon the digestive processes have been observed. However, "prevention is better than cure" in surgery as in medicine, and the fact that most pancreatic fistulae follow upon the drainage of pancreatic cysts must, I think, compel the question as to whether primary anastomosis of pancreatic cysts should not replace marsupialization and drainage as the standard treatment for pancreatic cysts.

Naturally the suggestion must be treated with reserve and judged primarily upon the mortality figures. Unfortunately, the method has not been

sufficiently frequently applied to give reliable data in this respect, but so far as the method has been used it has given a good account of itself and compares very favourably with marsupialization, which carries an appreciable mortality. Lahey and Lium (1937) collected 8 cases of primary anastomosis as a treatment for pancreatic cyst, without any mortality and with uniformly good results, one of these cases is included in this present review. Clearly the method is deserving of an extended trial and may well prove to be the treatment of choice in the future.

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# PAROXYSMAL HYPERINSULINISM DUE TO ISLET-CELL TUMOUR OF THE PANCREAS

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ENDOGENOUS hypoglycaemia was first recognized as a clinical syndrome by Seale Harris in 1924, following the recognition of the effects of overdosage of insulin.

In 1927 Wilder, Allan, Power, and Robertson demonstrated that neoplasms of pancreatic islet tissue may produce excessive amounts of insulin and cause hypoglycaemia. The first successful removal of an islet-cell tumour, with complete remission of the symptoms due to hypoglycaemia, was recorded by Howland, Campbell, Maltby, and Robinson in 1929. Since that time the number of successful cases has grown, but islet-cell tumours must still be regarded as rare. Meyer, Amtman, and Perlman (1941) were able to find records of 53 cases successfully treated surgically and we have been able to find records of 9 more cases and add 1 case of our own—Windfeld, 3 cases (1940), Rudd and Walton (1941), Conn and Conn (1941), Quarrier and Bingham (1942), Beek, Haex, and

Kooreman (1942), Rayner, Rogerson, and Gaymer Jones (1943), and Lups (1944).

## CASE REPORT

**HISTORY**—The patient, a schoolboy aged 13 years, was referred to J. MacD. H. by Dr D. Wallace, of Wrexham, as a probable case of 'petit mal'. During the past twelve months he had had several attacks of disturbed consciousness, occasionally associated with twitching of the limbs and face. The twitching was usually bilateral, but more pronounced on the left side. He did not always lose consciousness during these attacks, but often was unable to speak, and his mother had always noticed a "glazing of the eyes". He was first seen on April 10, 1945, and during the previous month the attacks had become more frequent, occurring about once a week. They had usually been in close relation to meals, either immediately before or after, and occasionally they occurred after exercise. He had never noticed any excessive hunger, but his mother said that his appetite was much greater than usual in a boy of his age. Although the description of the attacks suggested



'petit mal', some of the lapses of consciousness were followed by long periods of deep sleep or even stupor, from which it was difficult to rouse him. This raised the suspicion that hypoglycæmia might be the cause.

The boy is highly intelligent and his own verbatim description of the attacks is interesting. "The first attack which I had was in June, 1944. I was having dinner when my mother noticed that I was dropping the food on the tablecloth and that I was eating hardly any of it. She also noticed that my eyes were glazed. I was taken upstairs and put to bed, where I fell asleep immediately and slept for about three hours. When I awoke I did not remember anything and I only know what happened because I was told. The majority of the fits were not like this one, however. They usually occurred near to a meal time or after I had been running about. During these attacks I could not keep still and I had little control over my limbs. The left side of my body was usually worse than the right. I could usually keep still after a rest of about an hour. After one fit I slept for about five hours and when I woke up I could not remember anything about it. I had one bad attack on the football ground while watching a match. It was a very cold day and I began to feel restless and kept falling back against the people behind me. After watching the match for about half an hour my legs seemed to lose all feeling and I collapsed. I was in a daze and can dimly remember a man moving my arms about to wake me up. I got up and found that I could walk and my uncle started to take me home when I collapsed again,

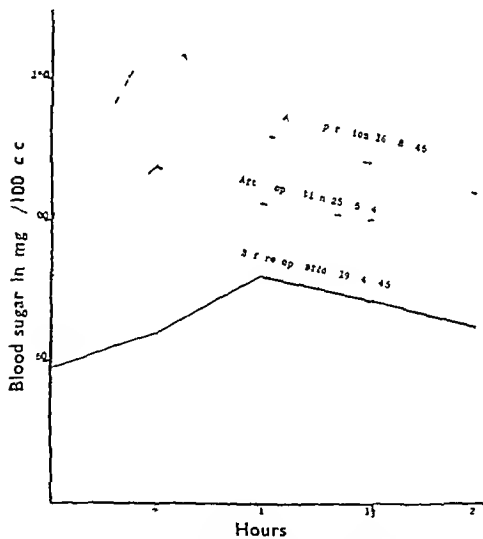


Fig 365—Oral glucose tolerance curves before and after operation. 50 g of glucose given by mouth.

so a taxi was sent for and I was taken home and put to bed, where I slept for two hours. When I woke I could only remember small parts of what had happened to me and thought at first that I had been dreaming. I could not remember seeing any of the football match. I had a headache for about an hour after waking up. When I felt the last fit coming on I had a dose of glucose and I was all right in about fifteen minutes. (This was after the presumptive diagnosis had been made and he had been told to take glucose if he felt an attack beginning.) During at least one of the fits I had difficulty in talking. My teeth were grinding together and my tongue curled up and I could not uncurl it for about five minutes. After lying down for half an hour I recovered."

ON EXAMINATION (April 10)—There were no abnormal physical signs of any kind. The B.P. was 125/60. X-ray films of the skull showed no abnormality.

On April 11 the blood-sugar after fasting for twelve hours was 56.5 mg per cent. He had no fit on the day this estimation was done, but had two more during the week before he was seen again on April 17. An oral

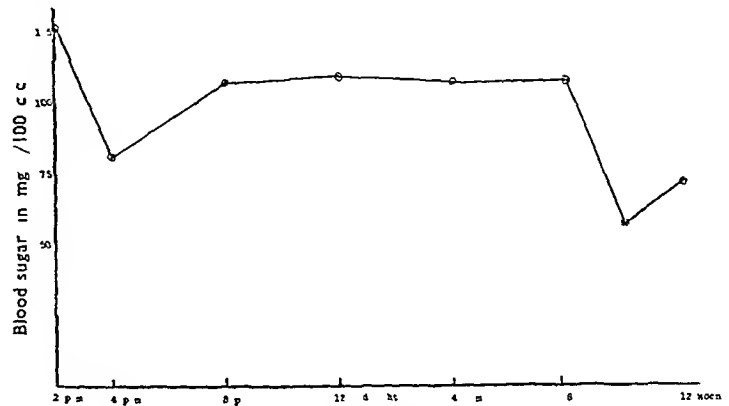


Fig 366—Diurnal variation in blood-sugar levels on normal hospital diet.

glucose-tolerance test on April 19 after a twelve-hour fast gave the following figures—

Fasting blood-sugar	47.5 mg per cent
4 hour after 50 g of glucose	60 mg " "
1 " " 50 g " "	85 mg " " (Fig 365)
1 1/2 hours " 50 g " "	72 gm " "
2 " " 50 g " "	65 mg " "

A diagnosis of endogenous hypoglycæmia was thus established and the possibility that it was due to an islet-cell tumour was seriously considered as there was no evidence of any other endocrine disease.

He was transferred to the Staffordshire General Infirmary on May 1 for further investigation, to be followed, if thought necessary, by laparotomy and exploration of the pancreas. No further fits occurred. A fractional test-meal showed no abnormality of gastric secretion and X-ray examination of the alimentary tract showed no abnormality.

On May 2 the diurnal variation of the blood-sugar on the ordinary hospital diet showed low, but not "hypoglycæmic" levels about three hours after the main meals of the day, namely, breakfast and the midday meal (Fig 366).

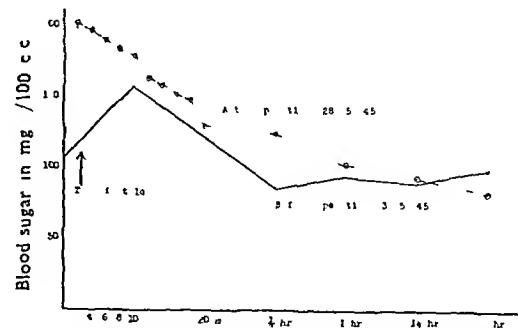


Fig 367—Glucose tolerance curves before and after operation following intravenous injection of 10 g of glucose.

On May 3, on attempting to carry out an intravenous glucose-tolerance test, the boy fainted after 10 g of glucose had been injected into an antecubital vein. Unfortunately a blood sample was not taken until ten minutes had elapsed, so it is impossible to say whether the transient lapse of consciousness was due to hypoglycæmia, but the test was repeated on May 8 after



injecting 20 g of glucose intravenously during about three minutes and blood samples were taken at two-minute intervals during the first twenty minutes of the

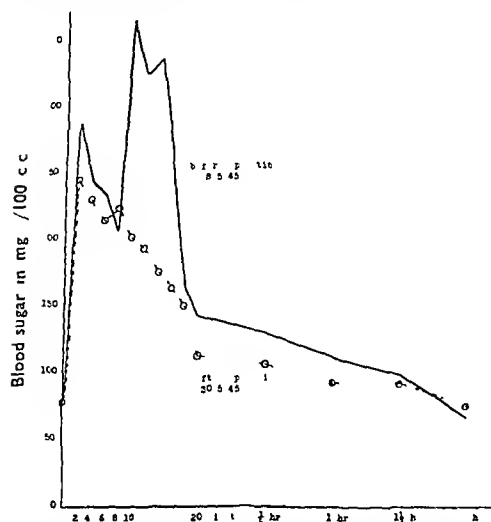


FIG 368—Glucose tolerance curves before and after operation following intravenous injection of 20 g of glucose

test. An immediate rise in the blood-sugar was observed, followed by a sharp fall during the first eight minutes of the test and then by an even greater rise (Figs 367, 368). These observations were made after a twelve-hour fast. Ten minims of adrenaline injected subcutaneously produced a rise in blood-sugar, reaching a maximum in two minutes, but there was no secondary "kick" in the curve as in the one following the injection of 20 g of glucose (Fig 369).

Although no conclusive evidence is furnished by these blood-sugar curves, the whole clinical picture strongly suggested a diagnosis of islet-cell tumour and it was decided to perform an exploratory laparotomy. This was done by B. R. S. on May 14.

**AT OPERATION.**—Under ether anaesthesia the abdomen was opened through an upper right paramedian incision. During the early stages of the operation the pulse became rapid and the breathing irregular, so 40 g of glucose were injected intravenously. On palpation of the pancreas a tumour about the size of a pea, firmer than the surrounding pancreas, was soon felt in the head. The gland was then exposed through the gastrocolic omentum. There was some difficulty in obtaining a full exposure of the pancreas as the lesser sac did not extend to the right beyond the pyloric antrum. A careful search revealed no other pancreatic tumours. Further examination of the nodule in the head of the pancreas gave the impression that it was partly within the duodenal wall at the level of the ampulla of Vater, so much so that it was decided to attempt its removal through the duodenum, but palpation through an incision into the bowel showed that it was not actually in the duodenal wall. It became obvious that the best approach would be from the posterior surface of the head of the pancreas.

After closure of the incision into it, the duodenum was mobilized and the head of the pancreas exposed from behind. The gland was incised over the tumour, and as the latter did not appear to have a satisfactory capsule it was resected together with some surrounding pancreatic tissue, the rather free bleeding being controlled by fine catgut sutures.

In spite of the risk of damage to the neighbouring ducts a complete removal was thought to be necessary, as the tumour was very small and even a fragment left behind might have been sufficient to cause hypoglycaemia.

A stab drain was left down to the duodenum and the abdominal wound closed.

The boy's convalescence was satisfactory, and as there was nothing more than a little scrous discharge from the drain it was removed on the fifth day.

The operation was finished at 12.30 p.m. and at 2.15 p.m. the blood-sugar was 184 mg per cent, at 3 p.m. 210 mg per cent, and at 4 p.m. 200 mg per cent. The following day the blood-sugar levels were as follows: 10 a.m. 141 mg per cent, 12 noon 109 mg per cent, 2 p.m. 108 mg per cent, 4 p.m. 113 mg per cent. The glucose-tolerance tests, oral and intravenous, which had been carried out in the pre-operative period were repeated under similar conditions during convalescence, and although the fasting blood-sugar still remained at a rather low level it was higher than before. The sharp fall in blood-sugar observed in the 20-g curve before operation was not found afterwards (see Fig 368).

The boy has now been under observation for five months and no further fits have occurred. An oral glucose-tolerance curve on Aug. 16 gave a curve more nearly normal.

**HISTOLOGICAL EXAMINATION OF THE TUMOUR.**—The tumour consisted of a roughly spherical mass approximately 1 cm in diameter, yellowish-grey in colour, with a shaggy surface and hard consistency. It was fixed in formal saline.

The mass may be divided for convenience into an outer and inner zone, but these blend at their junction. The peripheral zone, of variable thickness, consists of acinar cells, occasional islets and ducts, closely resembling, and probably identical with, normal pancreas. This zone extends over approximately three-quarters of the circumference, the remaining quarter shows the inner zone at the surface. The inner zone consists of hyaline connective tissue, in which are set, first, duct-like structures, with a clear lumen, lined by tall columnar epithelial cells, some of which contain material resembling mucin which stains pink with mucicarmine, and secondly, collections of cells closely resembling islet cells, arranged about wide blood-vessels, mostly of capillary type. The outer and inner zones interdigitate where they touch, without clear division. Furthermore, several of the islets

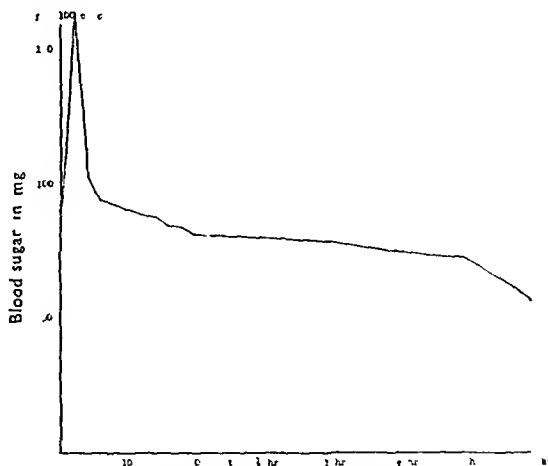


FIG 369—Blood sugar curve following subcutaneous injection of 10 minims of adrenaline

of the peripheral zone, where they abut upon the inner zone, are unusually large for normal pancreas and form a sort of transition towards the concentrated islet tissue of the centre, where the islet collections and capillaries are much larger still. Again, a few acinar cells are set in the fibrous tissue of the outer part of the inner zone. The ducts of the peripheral zone are set

# PAROXYSMAL HYPERINSULINISM

in trabeculae of fibrous tissue, as in normal pancreas, whereas the duct-like structures of the centre often immediately abut upon collections of islet cells without interposition of fibrous tissue.

Evidence of malignancy must now be considered. The appearance of islet cells in vessels is probably an artefact, due to section cutting of the spongy tissue of islets. For instance, Fig 373 shows a capillary and islet

and occurs in a variety of dissimilar diseases. Hims-worth (1943) classifies the causes of endogenous hypoglycaemia as follows —

- a Excessive Removal of Sugar from the Blood —*
- i Excessive exercise
  - ii Low renal threshold for glucose



FIG 370 — General view showing irregular distribution of fibrous tissue. Interdigitation of different cell-groups. Islet-collections seen to touch some large ducts. ( $\times 12$ )



FIG 372 — Capillaries and islet-collections abutting directly upon some 'ducts', whereas other 'ducts' are set in fibrous tissue, as in normal pancreas. ( $\times 165$ )

cells inside a duct-like structure lined by columnar epithelium. No mitotic figures were seen. The variations in morphology consist of duct-like structures and islet-like structures, but no anaplastic variations are seen — there is no de-differentiation. On the other hand, the fibrous tissue does not form a complete capsule and the interdigitation of almost or quite normal pancreas and islet masses may be urged as evidence of 'invasion'. Collections of islet cells, unquestionably larger than any seen in normal pancreas, are seen peripheral to the 'capsule'. No compression of surrounding tissue is seen.

## DISCUSSION

- i **Diagnosis** — Although islet-cell tumour is rare, endogenous hypoglycaemia is not uncommon.
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FIG 371 — Interdigitation of the constituents — the larger in fibrous tissue, the smaller in islet — collections. Acinar cells are well seen. ( $\times 60$ )



FIG 373 — "Duct" in dense fibrous tissue. The appearance is thought to explain the 'embolism' of various authors. Islet-cells and a capillary in lumen. ( $\times 165$ )

## *b Diseases of the Liver —*

- i Acute necrosis
- ii Certain cases of chronic inflammation
- iii Widespread secondary carcinoma
- iv Von Gierke's glycogen disease

## *c Disorders of Endocrine Glands —*

- i Hyperinsulinism
  - $\alpha$  Islet-cell tumour,
  - $\beta$  Islet-cell hyperplasia
- ii Hypopituitarism
- iii Addison's disease

## *d Idiopathic Spontaneous Hypoglycaemia*

The clinical diagnosis of endogenous hypoglycaemia should present no difficulty if the clinician is aware of the symptomatology, which is in no way different from that of insulin overdosage.

symptoms have been thoroughly studied during the past few years since the introduction of insulin therapy into psychiatric practice and may be classified as follows —

*Mild Symptoms*—Fatigue and lassitude, often accompanied by a feeling of faintness and hunger. Epigastric discomfort, sometimes amounting to severe abdominal pain. Sweating, pallor, and vertigo. Drowsiness, tachycardia, palpitation, extrasystoles, and occasionally precordial pain.

*Moderately Severe Symptoms*—Any of the above mild symptoms may be present in exaggerated form. In addition, there may be brief mental disturbances or lapses of consciousness resembling 'petit mal'. More florid psychiatric symptoms include depression, euphoria, confusion, and occasionally violent behaviour. States resembling alcoholic intoxication occur frequently. In many cases a disturbance of sleep rhythm occurs and conditions resembling Parkinsonism have been described. Hysterical behaviour, loss of memory, and aphasia have occurred.

*Severe Symptoms*—Any of the above symptoms may alternate with attacks of coma, with or without convulsions. Many of the cases described were at first regarded as epileptic. The coma and stupor may be very prolonged and suggest some serious intracranial lesion such as tumour or vascular accident. Violent delirium may occur.

The physical signs are negligible, even during attacks of coma, but occasionally disturbances of tendon reflexes and extensor plantar reflexes are found. It is unusual for any abnormality to be found in the intervals between attacks.

It is usually easy to recognize destructive disease of the liver, Addison's disease, and pituitary cachexia. The greatest difficulty is in differentiating between 'idiopathic' or so-called 'functional' hyperinsulinism and the hyperinsulinism due to hyperplasia of the islets of Langerhans or islet-cell tumour. Direct evidence of the existence of islet-cell hyperplasia is difficult to establish. There are many records of hyperinsulinism having been relieved by partial pancreatectomy, although no islet tumour was found. Some of these cases have been regarded, perhaps on slender grounds, as examples of islet-cell hyperplasia. The small size of islet-cell tumours and their not infrequent multiplicity make discovery and surgical cure difficult. It should be borne in mind that they may lie outside the pancreas, as in the case reported by Rudd and Walton (1941). If our submission that these tumours are in the nature of heterotopia be correct, search for them should include a much wider area than the pancreas and embrace the duodenum, jejunum, and stomach, where pancreatic heterotopia has been shown to occur.

From the point of view of clinical behaviour J. W. Conn has divided endogenous hypoglycæmia into two broad groups—stimulative hypoglycæmia and fasting hypoglycæmia. In 'functional' hyperinsulinism the stimulative type of hypoglycæmia is said to occur. A precipitous fall in blood-sugar follows the ingestion of large amounts of carbohydrate. The level of the fasting blood-sugar, however, remains normal, even when the dietary carbohydrate is restricted. The transient post-prandial attacks of hypoglycæmia are controlled by reducing the carbohydrate content of the diet. The

fasting type of hypoglycæmia is well illustrated by certain types of liver disease in which restriction of the dietary carbohydrate produces a low level of the fasting blood-sugar. A diet rich in carbohydrate controls this type of hypoglycæmia.

In organic hyperinsulinism, according to Conn and Conn (1941), both these types of hypoglycæmia occur. A low level of the fasting blood-sugar is always found and restriction of dietary carbohydrate depresses it further. At the same time, however, a stimulative effect may be seen in the fact that two to four hours after a meal the level of the blood-sugar is frequently far below that observed in the post-absorptive state. These authors regard their observations as evidence of an excessive stimulation, by the ingestion of carbohydrate, of the mechanisms involved in the rapid removal of sugar from the blood. They found in their case of islet-cell tumour, that the fasting hypoglycæmia, obviously the result of too much insulin, was associated with abnormal inhibition of glycogenolysis in the liver and with excessive combustion of sugar. The stimulative effect disappeared after removal of the tumour.

In our case there was a fasting hypoglycæmia and the diagnosis, at first only suspected, was more strongly suggested by this finding. There was also a 'stimulative' effect about three hours after meals, as shown by the variations in the blood-sugar throughout the day when the patient was taking a normal hospital diet (see Fig 366). It is also tempting to assume that the transient loss of consciousness following the intravenous injection of 10 g of glucose was the effect of 'stimulative' hypoglycæmia, particularly in view of the fall in blood-sugar observed in the first few minutes during the later test using 20 g of glucose. Definite conclusions from these isolated observations on a single case are impossible and repetition in further cases of islet-cell tumour is obviously necessary before their value can be assessed. We have been unable to observe the initial fall in blood-sugar in the 20-g curve in six epileptic patients who had no fasting hypoglycæmia. The oral glucose-tolerance curves before and after operation are of the flat type often seen in mild diabetes, although they are at a lower level. After a time the flattening disappears. This flat type of curve is not uncommon in hyperinsulinism, but in the present state of our knowledge it cannot be said that there is any infallible diagnostic procedure in cases of islet-cell tumour.

**2 Pathology**—It is submitted that the explanation in this case, and in many other published cases, lies in heterotopia—anlage—with possibly some degree of benign neoplastic proliferation. Nicholson (1921 onwards), as Professor Stewart observed, "almost single handed" in this country, studied the relationship between heterotopia and new growth (Stewart and Taylor, 1925). As we understand it, Nicholson maintained that there is "no borderland between malformations and tumours" and again "typical tumours come very close to malformations", "the displaced cells undergo their normal differentiation." It is noted that accessory pancreas is found between the layers of mesentery and within the wall of stomach or duodenum. A carcinoma of such accessory pancreas is described—hamartoblastoma, but "the truth

appears to be that cell-nests usually undergo differentiation together with the other tissues of the body. In rare cases they fail to do so. Tissue malformation or differentiated cell-nests are not predisposed to tumour formation."

Stewart and Taylor (1925) state that heterotopia of pancreas occurs in the subserous or submucous coats of the duodenum (also stomach and jejunum), islets are seen in some cases (Stewart and Hartfall, 1928). They describe an adenomyoma of the stomach containing pancreatic type of epithelium, undifferentiated duct-like structures are also figured. The blending of the various glandular groups of normal gut wall and pancreatic heterotopia resembles the findings in our case. Plain muscle was prominent—almost absent in our material. It is stated "specimens of differentiated heterotopic pancreas not infrequently show small areas of undifferentiated duct-like tissue obviously in excess of duct requirements." The important statement is made that "malignant tumours of accessory organs are extremely rare." Now this seems vital to the discussion on the evidence of malignancy in "adenoma" of the islet cells.

It appears to be established that islets arise in the embryo directly from duct-like (undifferentiated) structures. Barnard (1932) suggests that "the adenoma has replaced some of the pancreatic tissue proper and that fibrous tissue and ducts have persisted." Whipple and Frantz (1935) describe "duct-like structures. Whether they are to be interpreted as adult ducts from the original pancreatic tissue or new-formed tumour ducts it is difficult to say. The point is rather an academic one, since the origin of islet cells from duct epithelium has been demonstrated"—the suggestion is here made that further discussion is academic. It is submitted that this is not so and that the views herein set forth are very material to the issue, especially with regard to malignancy.

To summarize (1) The mass does not consist merely of islet cells, but includes "ducts" and cells resembling the external-secretory cells of the pancreas. (2) The position, in contact with the duodenum, is consistent with the embryological origin as a duodenal bud. (3) In the normal pancreas ducts are surrounded by bulkheads of fibrous tissue. Here islet collections often abut upon "ducts" without interposition of fibrous tissue. It seems unlikely that such fibrous tissue should disappear, and if so, suggestions that the duct-like structures are remains of pancreas invaded by tumour seem ill-founded. Again, the duct-like structures are too numerous to satisfy the conditions contemplated by such a view. The absence, often remarked by authors, of complete encapsulation in these tumours, and the interdigitation of almost normal pancreas with 'adenoma'—often deemed

evidence of invasion—are unlike the findings in adenomata elsewhere, at the same time the absence of signs of de-differentiation or anaplasia, and the usually excellent results (except in cases showing metastases) of operative removal, in spite of 'tumour cells' seen in vessels, are hardly consistent with carcinoma.

**Conclusion**—It is submitted that cogent evidence has been adduced to show that 'adenomata' of the islets of Langerhans are of the nature of heterotopia and that this view explains the presence of 'ducts' and 'invasive' growth and the 'absence of encapsulation' which have perturbed histologists inclined to regard the masses as true adenomata of islet cells.

## SUMMARY

A case of hyperinsulinism due to a pancreatic islet-cell tumour is described. The cerebral symptoms of the patient were entirely relieved by removal of the tumour. Certain features of the response to intravenous injection of glucose are described which have not hitherto been noted.

Histological evidence that these tumours are in the nature of heterotopia is presented.

Our grateful thanks are due to Professor M. J. Stewart and Professor H. P. Himsworth for helpful advice and criticism, and to Mr. T. C. Dodds for the photomicrographs.

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## THE PRESENT POSITION OF SURGERY IN THE TREATMENT OF BLEEDING PEPTIC ULCER\*

By GORDON GORDON-TAYLOR, C.B., O.B.E., SURGEON REAR-ADMIRAL

SOME apology is demanded from one who would venture yet again to write on this controversial subject, but the problem has interested me for a quarter of a century, and my own attitude towards the question has altered more than once during the years that have elapsed since the last Armageddon. I offer no excuse for changes in outlook that have from time to time controlled my scalpel, for no surgeon worthy of the name remains intransigently and adamantly bound to some particular line of therapeutic conduct which he may have cherished or championed heretofore, nor should his attitude towards any problem be crystallized beyond the power of reasoned persuasion, greater knowledge, and widened experience laudably modify opinions that formerly held sway.

The problem of the surgery of hæmorrhage from chronic peptic ulcer was discussed at considerable length by the writer (1937) in a previous number of the *BRITISH JOURNAL OF SURGERY*, to which the reader is referred. To many of the opinions expressed therein the author still adheres, a natural repugnance to mere repetition and the restrictions of space imposed by paper shortage suggest reference to previous communications by the writer (1935, 1937, 1939) on the subject, but there are other former views which require modification in the light of the more recent results of competent modern medical therapy.

Even before the outbreak of the present war, surgical interest in ulcer-hæmorrhage had fortunately produced certain important repercussions, including a re-awakening of medical enthusiasm over the treatment of this group of patients, greater vigilance and alertness in the medical observation and conduct of such cases, the exploration of new methods of assessment of the amount of bleeding in progress and its effect on the organism, the scientific employment of replacement-fluids of various kinds, including blood, and an earlier recourse to gastric feeding.

Therapeutic opinion still varies as to the amount of blood which should be administered by drip transfusion, computations of blood volume are now appraised as of greater accuracy than hæmoglobin readings in estimating severity of blood-loss in the early hours of the cataclysmic catastrophe. Especially in recurrent hæmorrhage, an estimate of the calibre of the artery bleeding in the base of the ulcer has sometimes been tentatively adumbrated by means of repeated blood-volume analysis, and more than an occasional appeal to surgery from the physician has been thereby evoked. The efforts of medical colleagues, more especially those under whose care in the Courtauld Research Wards of Middlesex Hospital during normal peace-time conditions were segregated many of the severe ulcer

hæmorrhages, have nowadays reduced "medical mortality" to a far smaller percentage than heretofore, so that the greatest judgement and caution must necessarily be exercised before pressing surgical intervention for patients overtaken by this alarming complication of a gastric or duodenal ulcer. Surgery required during active ulcer hæmorrhage indubitably carries least risk in the early hours of the bleeding, nevertheless, although Finsterer's "third day" may possibly be a critical period for operation, the successful results obtained by several of my surgical friends from interventions carried out at a later date in patients suffering from continued or recurrent bleeding belie the universality of the Austrian surgeon's dictum. The evidence seems to attest speed as an important factor in determining the issue of any surgical adventure for the control of gastric hæmorrhage, the extended experience of operators on both sides of the Atlantic fails to confirm the absolute inseparability of success and the employment of regional anæsthesia alone, as emphasized by Finsterer, Ferguson, myself, and others.

The purpose of this lecture is not to promulgate my own personal experience or to secure converts to any surgical *penchant* of mine in past days regarding these cases, but rather to paint a picture illustrating the results of the best modern therapy gleaned from the recent experience of many physicians and surgeons of many institutions. To those who have within the past few months so very kindly permitted me access to their notes and figures, who have given their time to discuss the problem with me, who have often with great trouble to themselves collected and collated information on the group of cases on which I desired their aid, my gratitude is deep and heartfelt.

The recent material which has been made available to me has emanated from certain of the voluntary hospitals of London, from hospitals of the London County Council and of the Middlesex County Council, as well as the larger Royal Naval Hospitals in this country, upwards of 1700 cases of ulcer hæmorrhage have passed under review for this address.

I have endeavoured for the lecture to survey the problem from a new angle, studying carefully the more recent statistics of physicians treating cases by non-operative measures, scrutinizing the histories of fatal cases where these have been available, and conjecturing what percentage, if any, of those who died might possibly have been saved had surgical measures been resorted to when non-operative treatment seemed and, in fact, proved unavailing. It becomes at once apparent how greatly the results of the non-operative treatment of gastroduodenal hæmorrhage of ulcer origin have improved in the past ten years. Dr Izod Bennett and his medical 'team' at Middlesex Hospital

\* Being the First Lettsomian Lecture, Medical Society of London, July 18, 1945



carefully classified (1938) cases of ulcer hæmorrhage admitted to the Courtauld Research Wards by means of blood-volume estimations. Their "severe cases" were those who had lost over 50 per cent of their total blood-cells, in 1935 the mortality in this group was 27 per cent, and in 1936 43 per cent, whereas in 1937 only 5 per cent died, and in 1938 only 11 per cent. In Bennett's own words, "*blood transfusion, correctly applied, is the most important single factor in saving life in gastroduodenal hæmorrhage*". Diligent scrutiny of the data concerning the 10 cases of this series who died as a result of ulcer hæmorrhage shows that 9 of them were suffering from chronic ulcer, and 1 from acute ulceration. One of the cases was under 50 years of age, and none under 40.

Of the 10 deaths of the series it is conceded by the physicians that 5 rapidly succumbed after admission to hospital purely from loss of blood, and, in the opinion of those in charge, had it been possible in the time available to have replaced the blood lost, some, if not all, of the fatal cases might have survived. Three other patients of the same group died from bronchopneumonia—so often, of course, a terminal event in the later stages of protracted bleeding, which might dubiously have been arrested by timely operation. Yet it is my considered opinion that surgery, if attempted, could only have saved at most one or two of the cases in Bennett's series that succumbed.

I am under a very special debt of obligation to Dr Avery Jones, of the Central Middlesex County Hospital, who furnished me with an analysis of 389 consecutive admissions for gastroduodenal hæmorrhage from June, 1940, to January, 1945, of whom 34 died, i.e., 8.7 per cent mortality. There were 87 ulcer hæmorrhages from chronic gastric ulcer with 12 deaths, i.e., 14 per cent mortality. There were 110 ulcer hæmorrhages from duodenal ulcer with 9 deaths, i.e., 8.1 per cent mortality.

But Dr Avery Jones afforded me still further assistance and most courteously provided me with notes of the fatal cases of ulcer hæmorrhage from June, 1940, to January, 1945, inviting my criticism. These fatal cases he had classified into (a) Cases in which surgery or further surgery seemed impracticable (b) Fatal cases despite an operation to control hæmorrhage (c) Fatal cases which in his opinion might have profited by surgery.

a Of 16 deaths which belong to Avery Jones's first group, a surgeon's critical attitude fails to convince me that operation could, or would, have saved any of that group. It is just within the bounds of possibility that if an immediate gastroduodenal resection had been performed for 2 cases which suffered from concomitant perforation and hæmorrhage instead of a mere suture of the perforation, these might have been saved. Another woman of 57 in the series might also have been a 'possibility', but the scales were certainly heavily loaded against a man of 67 who had been admitted for a fracture of the neck of the femur three weeks before his duodenal ulcer bled and perforated (!) I find little to support the view that any surgery would have bettered the results in this sub-group of fatal cases.

b Cases operated on for hæmorrhage who died—all these were of a 'forlorn' type, and their deaths call for no criticism or adverse comment from a surgeon.

c Cases which, according to Dr Avery Jones, might have profited by surgery. Of 7 in this category, possibly 1 case, a male of 56, might have been saved by surgical treatment. Various considerations relating to the other cases in this group convince me that surgery was unlikely to save any. Dr Avery Jones has wisely expressed his special anxiety over cases of chronic gastric ulcer who undergo recurrent hæmorrhage while in hospital and who are over 50 years of age. In his series of cases 10 fell into this category and 6 died (60 per cent). This able and experienced physician is led to the conclusion that more help should be obtained from the surgeons for this group of patient. In his opinion, clinical observations of grave significance in connexion with chronic gastric ulcer are—

- 1 A thickened tortuous radial artery
- 2 Age over 50—5 deaths out of 18 (28 per cent)
- 3 Severe pain preceding hæmorrhage—5 deaths out of 12 (40 per cent)
- 4 Pain persisting after hæmorrhage—2 deaths out of 4 (50 per cent)
- 5 Recurrent bleeding. Once—6 deaths out of 12 (50 per cent), Twice—5 deaths out of 8 (60 per cent). He writes "By selecting cases which come partly or wholly within this group a reduction in mortality from bleeding chronic gastric ulcer might be effected by early operation."

In 1936 I was involved in a debate on the treatment of hæmatemesis at the Medical Society of London. Sir Henry Tidy (1937), with whom I crossed swords on that occasion, gave an account of 30 cases of 'grave' or 'moderate' hæmatemesis or melæna admitted to his wards at St Thomas's Hospital during the years 1931-1936 inclusive. Of Tidy's cases 5 died, but 3 of these had accessory pathological conditions which indubitably rendered them little likely to respond favourably to either medical or surgical treatment. Of the remaining 27 cases, the help of the surgeons was invited in 2 cases, in 1 of which an unsuccessful operation was undertaken, in the other the surgeon declined to intervene. A remaining case of this series was operated on by another surgical team, a jejunal ulcer was dealt with and bled again, though the patient recovered, this was a case which would almost certainly have got well without surgery. In this series Tidy definitely proved his point that further surgery in his particular series of patients would *not* have improved the recovery-rate.

Thanks to the kind assistance of D. A. J. Ebrill, I was provided with information concerning 81 cases of ulcer hæmorrhage admitted to St George's Hospital from 1940 to 1944, both years inclusive. The mortality-rate was 11 per cent, and of the 9 cases who died all were patients in the "late sixties and the seventies", except 2 cases. One of the latter was a man of 42 who had a perforation and soon after suffered a hæmorrhage, which proved disastrous—the fatality of this combination, as will be emphasized in a subsequent paragraph, is proverbial. The other was a man of 45 years who

survived four days in hospital before succumbing from hæmorrhage, possibly in his case surgery might have helped, but no post-mortem was possible to afford further information. It is very dubious, therefore, if the employment of surgery would have made any difference to the results in this series, the age of almost all the fatal cases would appear to weigh heavily against any prospect of surgical success.

Thanks to the kindness of Dr E D H Cowen, I have been vouchsafed information about 15 cases of gastroduodenal hæmorrhage admitted to Westminster Hospital in eighteen months. A critical study of the fatal cases persuades me that in only 1 case might surgery have altered the result, and even that patient might well have been termed a 'very bad surgical risk'—a male, aged 61, was found unconscious in a pool of blood, but survived in hospital for four days, during which he had further attacks of hæmatemesis and required suprapubic drainage for retention of urine. At the autopsy there was found a gastric ulcer at the pyloric end of the stomach, measuring 5 in  $\times$  1½ in, which had eroded the splenic artery.

The effect of age on the mortality rate of ulcer hæmorrhage has already been mentioned, and will be referred to in a subsequent section. This is well illustrated in the figures from the Hillingdon County Hospital very generously placed at my disposal by Dr Cyril Barnes, of the Medical Unit, St Mary's Hospital. Under 50 years of age, the mortality in his series was only 3.5 per cent, over 50, 13.4 per cent. Under 60 years, the mortality was 5.7 per cent, over 60, 16.6 per cent. There were 23 deaths in the total series, of which 5 were undoubtedly moribund on admission and 3 other fatal cases were for various reasons extremely 'bad surgical risks'. Nevertheless, 18 cases in the series died from blood-loss despite transfusion, it is true that some of these fatal cases due to blood-loss had been seen by surgeons, who declined operative aid. The percentage of all the ulcer hæmorrhages admitted to the Hillingdon Hospital that were submitted to surgery was strikingly small—only 4 cases out of 275—yet the operators may be said to have 'done their stuff', since 3 of their patients recovered. Still, a surgical critic is left with the uneasy feeling that possibly, even probably, in this series, a more extensive employment of surgery might have saved a few of the 17 that died of blood-loss, and the total recovery-rate might have been raised to an even higher percentage than the creditable figure recorded.

Mr Norman C Tanner, of St James's Hospital, Balham, has generously placed at my disposal an analysis of 360 cases of ulcer hæmorrhage admitted to his wards between May, 1941, and March, 1945. There were in all 40 deaths, i.e., the total mortality-rate of ulcer hæmorrhage was 11 per cent. Tanner divides his series into three periods—

*a* A period when urgent operation was avoided whenever possible, and if performed was almost always a late intervention for persistent bleeding. The percentage of cases operated on during this first

period amounted to only 5.2 per cent, and surgery was resorted to on an average sixteen days after admission. The operations resulted splendidly in 9 out of 10 recovering, and included 7 gastrectomies, 1 ligation of blood-vessels supplying the ulcer, 1 closure of perforation in patient bleeding, all recovering. The 1 operative fatality followed a gastro-jejunoscopy with tampon of a bleeding duodenal ulcer. The total mortality in the group, whether medically or surgically treated, was 9.8 per cent, and the average age of the fatal cases was 62 years.

*b* A period where operation was more readily undertaken, the percentage of cases operated on was 15—not a very 'staggering' percentage. In this series, operation was undertaken much earlier—usually 36 hours after admission—all the operations were gastrectomies, but 4 died out of 9. The mortality for the whole group, whether treated by non-operative measures or by surgery, was 20 per cent, doubtless so high because the number of aged patients in the group was much greater (33 per cent were over 60).

*c* A period where operation was performed relatively early, but where the simplest surgical methods for arresting hæmorrhage were employed. The percentage of cases operated on was about 10.5 per cent, and the average time of operation was 3.7 days after admission. Of the patients submitted to surgery, 8 lived out of 11 (73 per cent recovery rate). A very remarkable case in this group was an "atheromatous" male of 79 years in *extremis* from his third collapse from duodenal hæmorrhage, whose blood-urea was 140 mg, and who was operated on on the fifth day. The mortality of this third group, whether medically or surgically treated, was only 8.5 per cent. The average age of the fatal cases was no less than 66 years.

It will be seen from these analyses from different institutions that wise and skilled medical treatment and good surgical judgement have paid fine dividends. H C W Nuttall, of Liverpool, in 11 years found it necessary to operate upon 16 cases of profuse ulcer hæmorrhage, of whom all recovered except one patient who had also a perforation of the bleeding duodenal ulcer. My friend H W S Wright has saved 3 out of 4 'late' recurrent ulcer-hæmorrhages of desperate character by urgent surgery, while bleeding was still in progress. At one large Naval Hospital from 1939-1944 inclusive there were 2 fatal ulcer hæmorrhages out of 69 cases of varying severity, some very slight. One death was a case of jejunal ulcer, the other a large duodenal ulcer in a man of 46, who continued to bleed, received 12 pints of blood during his sojourn in hospital, and died on the tenth day. In neither case was a surgical opinion invited until the day before death, when operation would merely have been wasteful of time. At another large Naval Hospital there was only 1 death among 45 ulcer hæmorrhages, yet that fatal case was in hospital for three months with recurrent hæmorrhage, and received in all 20 pints of blood, but no surgical aid was vouchsafed him (!). On the other hand 2 recurrent ulcer hæmorrhages were saved by urgent operation at Haslar, and another case of recurrent hæmorrhage from a chronic ulcer on the lesser curve of the stomach, under treatment in an Auxiliary Naval Hospital, was



brought to a successful issue by the surgical enterprise of Surgeon Lieutenant-Commander E H Murchison, R N

Ivor Lewis, from his extensive experience at the North Middlesex County Hospital, Edmonton, is inclined to think that the desirability of surgical treatment should at least be discussed in all patients in whom the hæmoglobin is under 40 per cent and who are over 40 years of age. Recently, out of 7 consecutive surgical interventions by this able surgeon for ulcer hæmorrhage all recovered, the patients were all over 40 and had suffered a second or third recurrence of bleeding during the 'hæmorrhagic phase'. In 5 a partial gastrectomy was performed, in 2 an elliptical resection of an ulcer of the lesser curve.

Perhaps the most wonderful series indicating the value of co-operation between physician and surgeon in the treatment of ulcer hæmorrhage is that kindly furnished me by Chase Farm E M S Hospital. The figures are concerned with the results of treatment of 81 cases presenting evidence of considerable gastroduodenal bleeding admitted to hospital between 1940 and February, 1945, in 50 of these the hæmoglobin had fallen below 50 per cent, and in 4 below 25 per cent. Four cases in the series died, i.e., a mortality-rate of less than 5 per cent, but this fatality-rate would doubtless have been much higher—possibly doubled, perhaps trebled—had it not been for the excellent judgement of Dr Allan Birch, who transferred a number of cases to his brilliant surgical colleague, R L Galloway. Of 11 surgical interventions 11 lived. This series shows *par excellence* the achievement of a physician and surgeon working in close unison.

#### A PERSONAL SERIES OF OPERATIONS DURING THE PERIOD OF HÆMORRHAGE OF CHRONIC ULCER

In the preceding pages I have largely quoted the experience of others chiefly obtained during the recent war years, but I am also anxious to place before readers a personal experience of almost a surgical lifetime comprising 71 operations performed *a chaud* during the hæmorrhage period for bleeding chronic peptic ulcer. The appended table brings the list of my interventions up to date, the cases seem divisible into four separate periods of surgical activity characterized by varying zeal on my part in the employment of operative methods in the treatment of ulcer hæmorrhage. The table does not include interventions for the hæmorrhage of acute ulcer, since surgical undertakings for the bleeding of an acute peptic ulcer date back to a distant past, and the writer has nothing to add to information contained in previous communications. Drip transfusion nowadays renders operation almost invariably unnecessary in this type of case, nevertheless, even to-day rare fatalities are known to occur from the bleeding of acute peptic ulcer.

In the period 1933-39 I may have been swayed a little unduly towards surgery by reason of the dismal results of the non-operative treatment of

ulcer hæmorrhage during the preceding period 1926-33, as evidenced by my own personal experience and results emanating from the non-operative measures for ulcer hæmorrhage among in-patients in the Middlesex Hospital and certain other institutions about that time, when the death-rate from hæmorrhage from proved ulcer cases treated by non-operative measures without or with only scanty and sporadic transfusion amounted to upwards of 24 per cent.

Table I—SUMMARY OF 71 OPERATIONS PERFORMED DURING HÆMORRHAGIC PERIOD FOR BLEEDING CHRONIC PEPTIC ULCER (PERSONAL SERIES)

PERIOD	OPERATIONS	RECOVERIES	DEATHS	PERCENTAGE MORTALITY
A 1919-24	22	20	2	9
B 1924-26	10	6	4	40
C 1926-33	10	8	2	20
D 1933-39	Early operation 18	17	1	5.5
	Late operation 11	7*	4	36
	Total 29 but amended 27 (2 hopeless cases excluded)	24 24	5 3	17 11

\* Two of the four fatalities were hopeless cases

During this period 1933 to 1939 I was again vigorously exploring surgical methods in an endeavour to improve the results in ulcer hæmorrhage, and our therapeutic armamentarium was reinforced during that period by the introduction of the "continuous intravenous blood-drip" by Marriott and Kekwick. At this time I dealt surgically with 29 patients, of whom 18 were early cases, many being operated upon within twenty-four hours of the onset of bleeding. Only 1 of these succumbed, death in that case was said to have been due to bronchopneumonia, probably related to the presence of some very septic teeth, perhaps to the general anæsthetic and the too liberal administration of morphine. The mortality in this series of early operations was therefore 5.5 per cent.

Of the 'late cases' operated upon in the period of six years preceding the outbreak of the present war no less than 4 patients died from various causes, some of these were 'forlorn hopes', and late operation in my experience has been fraught with a far heavier mortality than early surgery in this class of case.

#### THE PRELIMINARY MANAGEMENT IN CASES OF HÆMATEMESIS AND MELÆNA

This has been discussed by me in previous communications, it suffices merely to reiterate three recommendations already made—

1. In every case of hæmatemesis or melæna, whatever the cause, immediate steps should be taken to make contact with a transfusion organization.

2 It is desirable that every case of hæmatemesis of any severity should be transferred to a fully organized and equipped institution. An exsanguinated patient can be moved with the drip transfusion running, when this seems indicated ('*travelling transfusion*')

3 Early consultation between physician and surgeon, for which this lecture is a plea

### INDICATIONS FOR URGENT SURGERY DURING THE HÆMORRHAGE PHASE

It cannot be insisted too strongly that the diagnosis of a chronic peptic ulcer must be established beyond a doubt before any surgical treatment for ulcer hæmorrhage is even thought of, since a motley collection of pathological conditions may share hæmatemesis as their prominent symptom. Urgent surgery, when employed to control the bleeding of a peptic ulcer, must only be directed against that alarming complication of an ulcer, the diagnosis of which is definitely established. The circumstances of the operation and the limitations imposed by the employment of local anæsthesia, should the latter be selected, preclude energetic abdominal exploration, and if surgery be deemed necessary for a bleeding peptic ulcer, the surgeon must be sure, be quick, and be gentle.

1 Immediate operation is indicated and may on rare occasions be practicable in cases of terrific bleeding, when it appears obvious that some large vessel has been eroded.

2 Urgent operation is required in the rare cases of concomitant hæmorrhage and operation (*see below*).

3 The possibility of urgent surgery should always be considered in patients over 50, especially males with a known chronic peptic ulcer, and perhaps more particularly a chronic gastric ulcer. In this group surgery is still more deserving of consideration, if the patient has a thickened, tortuous radial artery, if severe ulcer pain preceded the hæmorrhage, if pain persists after the hæmorrhage, or if recurrent hæmorrhage takes place in a patient under appropriate medical control.

4 The anxieties engendered by recurrent hæmorrhage in the above group suggest an appeal to surgery, since in Avery Jones's cases of chronic gastric ulcer in men over 50, half the patients died after one recurrent hæmorrhage and 60 per cent after a second bleeding.

5 Where pyloric or duodenal stenosis is present, or mid-gastric narrowing is considerable, hæmorrhage is more likely to persist or quickly recur, and the pathological condition may determine a decision to intervene surgically.

### DECISION TO OPERATE

Lest the reader should entertain the opinion that I am recklessly prejudiced in favour of surgery, I would venture to repeat what was written by me eight years ago: "Every case must be considered on its own merits, there can be no hard-and-fast rules. Antecedent disease and intercurrent illness, the previous habits of the patient, his physical conformation, and all that constitutes a sufferer a 'good or bad surgical risk' must be weighed carefully, the personal courage of the patient as well

as of the operator, the environment of the case, the experience and technical skill of the surgeon, are all factors which not only should influence the decision as to the desirability of surgery, but may also indicate the appropriate technique when the abdomen has been opened." R. L. Galloway, of Chase Farm Hospital, believes that operation should only be carried out by someone "who is nimble with his hands and can carry out the operation at the maximum possible speed." Ivor Lewis, of North Middlesex Hospital, thinks that no surgeon should operate on a case of bleeding ulcer during the 'hæmorrhagic phase', whose mortality for 'cold' gastric surgery is more than 5 per cent. This opinion coincides exactly with that of his colleague, W. J. Ferguson, of the West Middlesex Hospital, one of the finest gastric surgeons whom I have been privileged to watch.

### THE NATURE OF THE SURGERY EMPLOYED

Although those surgeons who have had experience of operation during the period of acute hæmorrhage from chronic peptic ulcer exhibit a proclivity to the performance of partial gastrectomy, I am most anxious to protest that the treatment of ulcer hæmorrhage in my own hands is not synonymous with gastrectomy. No one technique is appropriate to every case for which operation has been judged necessary. The various surgical measures which I have myself employed have been described and illustrated again and again in previous papers, and I have nothing to add except to describe and illustrate Judin's technique of dealing with a bleeding penetrating duodenal ulcer.

The 'snail-like' method of closure of the duodenal stump (technique *en escargot*) is strongly recommended by him in cases of acute hæmorrhage from large penetrating callous ulcers of the duodenum where a complete defect of the posterior duodenal wall exists. A free mobilization of the antero-lateral wall of the duodenum is imperative, including the division and separation of all adhesions and adventitious membranes immuring the gut at the back of the abdomen beneath the gall-bladder or hepatic flexure. The anterolateral wall must be freed distal to the ulcer or stenosis for at least 4 to 6 cm, not only along the whole upper horizontal first portion of the duodenum, but also along the 'angle'. The precise technique of inserting the sutures can be seen in the accompanying illustrations (*Figs 374, 375*) which are from Judin's own pen. The particular merit of the method lies in the use of the bunched-up duodenal stump to tampon a gigantic ulcer penetrating into the head of the pancreas. Judin's only apprehension, when first he devised this technique, was lest the inner catgut suture fixing the two or three twists of the 'snail' should undergo premature digestion, permitting the 'snail' to uncurl and escape through the superjacent layer of sutures. The Moscow surgeon's experience of the method now amounts to upwards of a hundred cases over a period of ten years, and only once in the earliest year of its essay did this untoward accident occur.

My own experience of this method of closing the duodenal stump is necessarily small, but I have

found it valuable in difficult cases of penetrating duodenal ulcer, however, the opportunity of employing the technique in the treatment of acute hæmorrhage from a duodenal ulcer has so far been denied me

Sir Henry Tidy (1944) has pointed out the 'territorial' differences in the character and *locale* of peptic ulcer, not only between this country and the Continent, but also between London and England and Scotland, he has also stressed the importance of social environment in this connexion, and has uttered a timely warning about the criteria of satisfactory medical treatment and a reminder that when a first course of medical treatment fails, a second course is often successful. 'Territorial' considerations may therefore play some role in explaining the numbers of operation for acute hæmorrhage performed by Finsterer, Judin, and others. Judin (1943), however, has gloomily described his feelings as a surgeon of a famous special Emergency Hospital, when for the thirtieth, fortieth, and even the fiftieth time it has been his misfortune in the post-mortem room to view the erosion of an artery in the crater of a large ulcer, yet quite accessible for a surgical operation. It is not difficult to understand his surgical bias in view of this experience.

The famous Moscow surgeon has performed 134 gastroduodenal resections during *acute hæmorrhage*, avoiding operations upon very old persons, "except those who looked younger than they really were". There were 21 deaths in this series, but 4 'casual' fatal issues might be excluded from the computation, thus, a woman died six days after operation of infarction of the myocardium, a man died a week after gastrectomy with sepsis and profound jaundice, autopsy revealing purulent calculous cholecystitis, an obstruction of the common duct by a stone, and gas infection of the liver and spleen. Two other patients died owing to faults in technique connected with blood transfusion: one from air embolus, noted during the transfusion and confirmed at the necropsy, the other perished from typical hæmolysis.

Judin considers separately a group of "desperate operations", when after frustrated hopes for recovery by means of conservative treatment or "hæmostatic transfusions" the patients were operated on, always without pulse, almost always unconscious, and in such degree of anæmia, that expectations of recovery were founded, not so much on operation, as on some miracle. He gives a few detailed examples of these cases, in which there were 9 deaths in 23 gastrectomies. Without these "desperate operations" the great majority of such patients would almost certainly have perished.

The 'forlorn hope' ulcer hæmorrhage, for which appeal, perhaps belated appeal, is made to surgery is sufficiently well known to operators, these cases have been described, particularly when success has crowned surgical effort, by myself and others in previous communications and addresses. Despite 'territorial' differences in the ulcer story, and in tribute to a great surgeon of a great Allied Power, here are appended accounts of two of Judin's own cases communicated to me, they have indeed been rescued from the jaws of death by courageous surgery.

## CASE REPORT

**Case 1**—A boy of 17, a waif, was making his way to Moscow from Kiev on the steps and buffers of trains. This journey in frosty weather lasted five days, during which time he got practically nothing to eat. At the station in Moscow the boy ate a kilogramme of brown bread straightaway, and was picked up there in a pool of bloody vomit. An ambulance brought him to Judin's clinic on Feb 25, 1933. Emaciated in the extreme, physically under-developed, looked 15, waxy pale, cyanotic. Pulse very weak and fast. Hæmoglobin 21 per cent.

The patient's faintness and emaciation, as well as his age, which seemed to negative the possibility of an ulcer, caused Judin to postpone operation.

At daybreak on Feb 26 another hæmatemesis 300 c.c. cadaver blood transfused. That day passed uneventfully, but in the night of Feb 27 another formidable collapse occurred: complete loss of consciousness, no pulse, pupils dilated. Anus paralysed, and spontaneous evacuations of liquid, tar-like stools. The almost-dead patient was given 150 c.c. more of cadaver blood. Pulse and consciousness returned.

At daybreak on March 1 there was again vomiting of crimson blood. Breathing was of the Cheyne-Stokes type, pulse hardly to be felt, and only in the carotid artery.

Judin had at his disposal about 1.5 litres of suitable blood. They gave him 330 c.c. and put the half-dead boy on the operation table. Laparotomy with hardly any anaesthesia. An enormous duodenal ulcer discovered penetrating into the pancreas, erosion of the gastroduodenal artery. A rather difficult resection performed according to the Polya-Finsterer method. A further 1100 c.c. cadaver blood transfused, this being a large quantity for a child. The pulse became excellent, cyanosis of lips and fingers disappeared. On March 3 patient quite fit. Hæmoglobin 27.7 per cent, erythrocytes 2,100,000. Was fed for the first time after nine days' starvation. On April 1 hæmoglobin 47 per cent, erythrocytes 2,780,000.

Discharged on April 24 in a thriving condition with hæmoglobin 64 per cent and 4,240,000 erythrocytes.

**Case 2**—One of the head engineers of the railway line from Moscow to the Donetz Basin—a man of 34—had for more than two years been suffering from a duodenal ulcer, and had become an inveterate morphomaniac. On Dec 10, 1938, a tar-like stool, and profound faintness. On Dec 23 profuse hæmatemesis and collapse. The special railway car, where this man was working, was uncoupled at a flag station, 150 kilometres from Moscow, and doctors from a near-by hospital were summoned to this. It happened at the very time of the Twenty-fourth Congress of Russian Surgeons in Kharkov, so that it was not an easy job to secure one of the few professors of surgery remaining in Moscow. The patient was transported from the car to the hospital and immediately operated upon. An enormous duodenal ulcer was found penetrating deep into the pancreas. In view of the patient's grave condition and the ulcer being inaccessible for resection, a ligature of the afferent vessels was performed.

During the night following the operation, the hæmatemesis recurred, and the next day the patient lost so much blood by repeated vomiting that his condition was considered hopeless. A few days later he was transported to Moscow by railway.

On Jan 2, on Judin's return from the Congress, he saw the patient in consultation. It was the ninth day after the first operation: the hæmoglobin was 18 per cent, erythrocytes 1,500,000. Hæmatemesis had ceased, although the stools continued black. There were no clear indications for a second operation.

On Jan 10 another intense hæmatemesis and profound collapse. The patient had now but 11 per cent of hæmoglobin left, and only 850,000 erythrocytes. With all possible precautions the patient was transported from Tushino to the Sklifassovsky Institute—about 10 miles.

At operation by Judin, the infiltration around the enormous ulcerous crater made it impossible to locate

On the operation table the patient was given 1250 c.c. blood, and when returned to bed an additional drip-method of transfusion was instituted. He thus received 2 more litres of cadaver blood in the course of twenty-four hours—a litre from one corpse, stored for six days, and a litre of eight days' standing from another corpse.



FIG 374—Judin's technique. Indicating the operation steps freeing the first part of the duodenum from the base of the penetrating ulcer and its conversion into a conical form.

exactly the previous ligatures on the upper and lower borders of the duodenum. The anterior wall of the duodenum was opened in a V-shaped manner. An enormous crater was discovered, in the centre of which both ends of a big eroded artery with protruding thrombi could be seen, in smearing the cavity of the ulcer with iodine Judin took care not to touch these thrombi. The duodenum was sutured like a cone, which permitted it to be folded in three twists like a "snail." With this "snail" Judin succeeded in tightly plugging the crater, fixing the stump with an additional row of sutures. The operation terminated in a wide gastric resection.

These 3½ litres of blood quickly effected a change in the patient's appearance and general condition. The hæmoglobin rose from 11 to 46 per cent, and later to 57 per cent. He has remained well ever since, steadily putting on weight and working hard.

#### HÆMORRHAGE AND PERFORATION

In previous communications I have written at some length on my own experience of the association of perforation and hæmorrhage occurring synchronously or successively, and expressed my own view

that it was probably in the best interests of the patient that these twin complications of peptic ulcer should happen together (!) Nothing has emerged from the untoward experiences of other surgeons to dissipate the dismal prognosis attaching

At Middlesex Hospital, H L McMullen had recently under his care a patient who within a few weeks suffered two hæmorrhages and two perforations of a duodenal ulcer. Admitted as an in-patient for severe hæmatemesis he perforated ten



FIG 375.—Representing the conversion of the cone into a snail-like form, and the employment of this to tampon the ulcer base

to those patients who bleed and then perforate or perforate and subsequently suffer gastric hæmorrhage. For example, Mr Ebrill, of St George's Hospital, satisfactorily sutured a perforation of a duodenal ulcer, a fortnight later a severe hæmatemesis occurred, from which the patient died in four days.

days later, the perforation was successfully sutured. A fortnight later another hæmorrhage occurred, and during the period of recovery from this a second perforation took place from which the patient succumbed. A history such as this lends some support to the practice of primary gastroduodenal resection in the treatment of perforated peptic ulcer as

advocated by Professor S S Yudin, of Moscow, in his well-organized Emergency Hospital (Sklifassovsky Institute) with its excellent first-aid and wonderful transport facilities McMullen's case is, of course, fortunately exceptional, and were primary gastrectomy to become the approved method of treatment for perforated peptic ulcer, doubtless the mortality-rate of this frequent emergency would assume a much higher figure in this country than obtains to-day

### THE ROLE OF SURGERY IN THE PREVENTION OF ULCER HÆMORRHAGE

In a previous number of the *BRITISH JOURNAL OF SURGERY* I have discussed such cognate subjects as the prospective protection afforded by surgical operation against hæmorrhage from ulcer, and the prospective mortality of an adequate operation to prevent hæmorrhage from a peptic ulcer. The conclusion was reached that in very experienced, competent hands an operation of resection or "resection-for-exclusion" (Finsterer) carried a mortality of about 3 per cent—a figure as great as, and possibly greater than, the risk run by the possessor of a peptic ulcer of death from hæmorrhage. An operation undertaken solely on grounds of prophylaxis against bleeding is therefore to be discouraged.

In the past, surgeons have sometimes been lulled into uneasy acquiescence in the situation, or a spirit of pious hope, by the oft-repeated assertion that fatal cases of ulcer hæmorrhage never occur in private practice, and that blood transfusion has scarcely ever been required or enjoined for this seemingly favoured class of sufferer (!) Nevertheless, during the years 1924 to 1933 many of my own fatal cases belonged to that very group whose future is alleged to be so rosy. Few physicians would venture to make such a fantastic claim to-day, or to assert that blood transfusion as at present employed probably costs more lives than it saves.

The time may come when medical science will of a certainty cure every ulcer of the stomach or duodenum, but until that golden era ulcer hæmorrhage, severe ulcer hæmorrhage, will continue to occur and recur, gravely menacing life and perchance ending disastrously. The problem of the bleeding peptic ulcer is certainly not one of surgery versus medicine, although without a doubt there are cases which operation alone may save. That a predominant percentage of ulcer hæmorrhages cease spontaneously or by reason of medical treatment, to which blood transfusion may have been added, is not denied, it is also freely admitted that the success which has followed early operation might well have attended an expectant line of treatment, but it is no less true that late surgical intervention consequent upon unsuccessful medical therapy is associated with mortality, therein lies the dilemma in treatment.

I am merely pleading once again that the surgeon be not excluded from the consultation until that last desperate stage of ulcer hæmorrhage, the anxieties of which neither physician nor experienced operator is anxious to shoulder. *Every case is to be regarded as a special problem deserving of the most careful attention.* Supreme judgement and self-restraint on the part of the surgeon will be of more

value to his patient than the acme of technical skill, indiscriminate operation cannot be too strongly condemned. The value of the continuous blood drip transfusion has proved inestimable, and is nowadays attested by all.

The pioneer is rarely the exploiter, and the man who would iconoclastically destroy an old edifice of worthy tradition and mark out the lines of a new one does not often live to see the walls begotten of his imagination rise. The caution and wisdom of experience, the obstinate conservatism of critics who would rightly and intransigently retain features which usage has triumphantly vindicated, the frank and ingenuous interchange of opinions, the mutual respect for differing viewpoints, the honest endeavour to attain agreement and promote advance, will in the fullness of time erect a temple of therapy retaining in its structure much that experience has already hallowed, but presenting also new bold bastions, the daring minarets and the stark pinnacles that shall bear witness to the devoted service of priests and acolytes carried in consummate perfection to the highest heavens.

The advocacy of surgery for the acute hæmorrhage of peptic ulcer practised by Finsterer, Yudin, the writer, and others since the last World War and promulgated specially during the years that preceded the recent Armageddon, drew on itself the fierce light of hostile criticism. But, as has been said before, the insolent innovation has produced at least this salutary repercussion that it made the physicians survey their position and practice more closely and more critically.

The steady decline in mortality of this special group of cases in my own hospital from that dismal percentage obtained during the decade 1924 to 1933 to the present small figure which at the outbreak of the present world conflict characterized the results of medical treatment, clearly betokens the wisdom of the segregation of the severe ulcer hæmorrhages in special wards under physicians with a special interest in the problem. The results emanating from the other hospitals which I have already quoted proclaim with no less certitude the great advance that medicine has made in the past ten years.

If in certain cases operation should appear probable or possible, it may be well for physician and surgeon alike to remember a critical "third day", since Finsterer's first forty-eight hours is still the optimum period for surgical attack in the bleeding of chronic peptic ulcer. Nevertheless, there is much evidence to-day that recovery may follow operative intervention at a much later period than that just mentioned. The wisdom of the physicians and the skilful hands of many surgical friends have rescued even 'late' cases on the very brink of the grave.

### SUMMARY

I Profoundly depressed by the fatality of ulcer hæmorrhage treated by medical measures in the early period after the last war I commenced to operate, where possible, on these cases, operation being associated with the transfusion of blood. Most were early operations, the mortality was 9 per cent.

2 After some years and for various reasons my own surgical zeal in regard to these cases waned, but was stimulated once again by the disturbing mortality-rate of 24 per cent attendant on cases of hæmorrhage of proved ulcer origin treated in the medical wards of Middlesex Hospital from 1924 to 1933. This figure coincided very closely with that reported from several other large hospitals.

It was further ascertained that a huge majority of patients with serious ulcer hæmorrhage seen by me in private practice between 1926 and 1933 and not operated on had succumbed, whereas 8 out of the only 10 operated on by me during that period survived, the 2 cases fatal being 'forlorn hopes'.

3 From 1933 to 1939 I again began to employ surgery and operated on nearly 20 per cent of the ulcer hæmorrhage cases coming under my notice. Of 18 cases operated upon within twenty-four hours of the onset of the bleeding only 1 died—a mortality-rate of 5 per cent. Of 11 cases operated upon 'late', 5 died. This contrast in fatality-rate between early and late intervention seemed strongly to support the experience of Finsterer, Arthur Allen, of Boston, U S A, and others.

4 The impertinent promulgation of a surgical doctrine for a malady regarded from time immemorial by the physicians as peculiarly their own re-awakened indignant medical interest, especially on questions of transfusion, prevention of dehydration, and early feeding, etc.

5 The results of the non-operative treatment of ulcer hæmorrhage have improved enormously in the past seven or eight years. The mortality now is only about 10 or 11 per cent, sometimes far less, despite the aged and infirm patients met with in many institutions.

6 There are even laudable signs of some dissatisfaction to-day among certain physicians concerning the results of medical treatment, including transfusion, in the more fatal chronic gastric (and perhaps the duodenal) ulcer hæmorrhages in males over 50, and there is an evident disposition to invite and seek surgical aid for these cases.

7 The very best results in the treatment of ulcer hæmorrhage appear to be forthcoming in those hospitals where co-operation between physician and surgeon is closest and the team-spirit is most evident.

8 Blood transfusion given at the rate of about 40 drops a minute is perhaps the most valuable single factor in the saving of life. The debt of medicine and surgery to the Marriott-Kekwick "drip transfusion" is immense.

9 The influence of age upon mortality has been demonstrated by many observers. Comparisons of the statistics of individuals, institutions, or of methods of therapy are worthless which do not take this factor into the reckoning.

10 My own contribution to the subject has been largely that of an irritant or provocative, re-awakening the interest of the physicians in their own subject, wherein the most valuable advances have been made in the past few years and the fatality of the condition notably lowered by their efforts.

In my anxiety to paint a true picture portraying the present position of surgery in relation to the hæmorrhage of gastric and duodenal ulcer, I have not hesitated to solicit the advice and help of numerous interested physicians and surgeons. For permission to avail myself of statistics emanating from institutions under their control I gladly acknowledge the kind co-operation of Surgeon Vice-Admiral Sir Sheldon Dudley, K C B, F R S, Medical Director-General, Royal Navy, Sir Allen Daley, Chief Medical Officer to the Hospitals of the London County Council, and Dr H N Cameron Macaulay, Chief Medical Officer to the Hospitals of the Middlesex County Council. To my many friends who have aided me so nobly I have already tried to express my indebtedness and gratitude in an earlier portion of the address, no less than the surgeons, the physicians have indeed proved themselves in this inquiry a loyal "band of brothers."

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## A MICRO-INCINERATION STUDY OF THE FLAT EPITHELIAL LAYER COVERING THE ALIMENTARY TRACT

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THE gastric and intestinal mucosæ are covered by a layer of flat epithelial cells which contains a variable number of diapedic cells and a network of capillaries (Duran-Jorda, 1945). Between the layer and the pits of the glands there is a kind of albuminous fluid which in some stomachs becomes clotted and produces a cast of the whole elements contained in the flat epithelial layer. This layer is very friable, and more so because it is bathed in the juices contained in the gastric and intestinal mucosæ. The link between the layer and these mucous membranes is very fragile, and it was for this reason that we were compelled to develop a new method of fixation



Fig 376



Fig 377

FIG 376—Gastric mucosa showing two layers (fvf, hæmalum and eosin)

FIG 377—Micro-incineration of Fig 376 in which only one layer can be seen. The one at the top was mucous material which has disappeared after incineration

to study the layer. This method will be referred to herein as "formalin vapour fixation" (fvf), and the fixation was carried out by submitting the tissues to formalin vapour in a closed atmosphere, at room temperature, for two to three days.

After its fixation the mucosa is ready to be dehydrated and passed through different alcohols to be finally blocked in paraffin wax. We have found this method very satisfactory for studying the nature of the flat epithelial layer, and it is owing to the lack of a suitable method of fixation that this structure has been overlooked by histologists, who have been using liquid fixatives which show only occasional pieces of the covering layer in the gastric and intestinal mucosæ. These portions have been mistaken for cellular elements deposited by accident on the top of the mucous membrane. The destruction of the covering layer can be better appreciated when one studies the photomicrographs published by numerous authors in regard to the different pathological processes of the gastric and intestinal mucosæ, in which can be seen portions of the mucous membrane still covered by remnants of this flat epithelial layer described by us.

As we have previously remarked, the presence of different cellular elements at the top of the mucous membrane is a well-known fact amongst histologists, and statements have been made to the effect that the material present on the top of the undamaged mucous membrane is clotted fibrin containing diapedic cells (Nedzel, 1943), but its real nature and physiological, protective function have never been interpreted. The material has always been dismissed as unimportant, and as being formed by desquamative cells, wandering cells, cellular remnants from the upper organs, and food debris, which are all included in a supporting background of mucus. It seems paradoxical then, that the supporting material does not stain with mucus stains. Using hæmalum and eosin, the supporting material, unlike mucin, does not take the basic stain but instead stains with the eosin. And if the gastric mucosa is stained by thionin, the covering layer does not take the stain at all. Occasionally, in the colon, the cytoplasm of a very small number of the mucous-membrane cells does stain with thionin, but not the whole mass of the covering layer as should be supposed. Some authors are very emphatic when describing the methods of mucin staining that it is very difficult to demonstrate the presence of mucin cells in the stomach and intestines, and have arrived at the conclusion that "The mucus in the stomach does not stain by any method unless freshly produced" (Mallory, 1942, Bolles Lee, 1937).

As a consequence of these uncertain methods of staining both the cytoplasmatic cellular mucus and the supposed mucus covering the mucous membrane, we decided to resort to a more drastic method of investigation, and after a careful consideration of the problem we concluded that the most satisfactory technique to reveal the organic nature of the flat epithelial layer described by us was to submit the tissues to micro-incineration. Then we could make a subsequent study of the remaining ashes.

Mucin is a compound protein consisting of a protein radical and a nitrogen-containing carbohydrate, glucosamin (Wells, 1918), and as there are no salts in its composition the mucin cannot leave any mineral ashes after incineration. This is a well-known fact by research workers who have used the micro-incineration method of studying the ashes contained in the tissues (Policard, 1923, 1929), and as the mucin does not leave any ashes after its incineration, the spaces occupied in the cytoplasm of the cells secreting mucin or pseudo-mucin are empty when the tissue is studied after incineration, as can be the case with parotid tumours or ovarian cysts. When describing the cells in the mucous membrane of the stomach, small intestine, and colon, micro-incinerators are quite definite that the empty spaces seen in the cytoplasm of some mucous-membrane cells are the places previously occupied

by the mucus, which does not leave any ashes (Scott, 1933) Then we can conclude that if the layer covering the gastric and intestinal mucosæ is basically formed by an accumulation of mucinous material, it will disappear after incineration and be substituted by an empty space (Figs 376, 377)

### MICRO-INCINERATION TECHNIQUE

To carry out these studies, we subjected to micro-incineration alternate slides of serial sections



FIG 378—The junction between the œsophagus and stomach in a rabbit. The layer can be seen passing from one to the other (f v f, hæmalum and eosin)

of the mucosæ to be investigated. From these sections, the first was stained with hæmalum and eosin, the second was submitted to micro-incineration, and the third was treated with a mucin stain. The specimens selected had previously been fixed by f v f and embedded in paraffin blocks. Occasionally, we incinerated one of the stained slides



FIG 380—Gastric mucosa. Notice the presence of the layer at the top (f v f, hæmalum and eosin)

after taking some photomicrographs of it as a control, and after micro-incineration we took more photographs of the same fields to compare the two

Our micro-incinerator was a heat-resisting cylinder of 1½ in diameter, wrapped with electric resistance wire and protected by an asbestos sheet. This produced just the right temperature, and we found

that by raising the temperature slowly we obtained the best results with less shrinking and less disturbance of the tissue and no bending of the glass slide. We timed our incineration accordingly: 2 min on, 2 min off, 2 min on, 2 min off, 3 min on, 2 min off, 3 min on, 2 min off, 4 min on—a total of 14 minutes in the incinerator. When the slide had cooled we put a cover slip on and sealed it with paraffin wax, and the observation of the ashes was done using a dark-ground condenser.

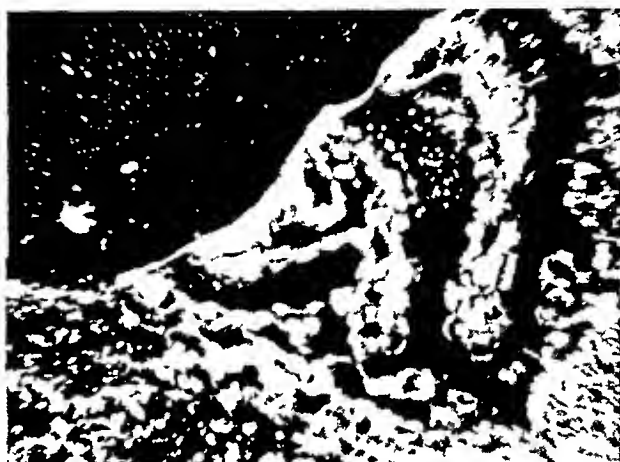


FIG 379—Incineration of œsophagus and stomach from serial section of rabbit as Fig 378, showing the layer passing from one structure to the other

After incineration, the section should first be observed under an ordinary microscope to see if the tissue is still black, in which case the incineration should be longer. If the slide has been well incinerated, the ashes under the ordinary microscope are white and can be seen very faintly.

The specimens of different mucosæ studied came



FIG 381—Micro-incineration of one field of the previous slide

from surgical specimens, as the protective layer is destroyed immediately after death, and we supplemented our investigations by making a further study of some specimens from mammal alimentary tract. These supplementary observations were especially gratifying in studying the connexion between the œsophagus and stomach, which we were not able to

investigate in the human gastric mucosa owing to the technical difficulties involved. The animals used for studying the histology of this anatomic region

explanation for this could be because of the presence of hydrochloric acid in the gastric mucous. The layer can be peeled off from the stomach if the

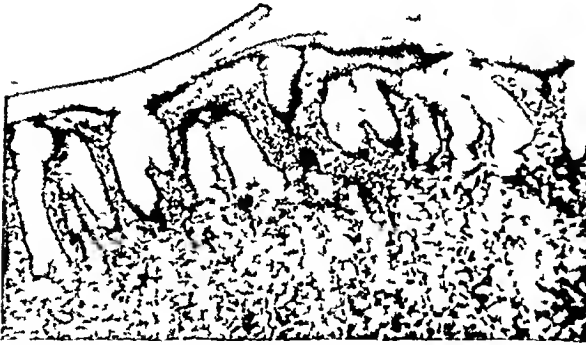


FIG 382—Gastric mucosa showing the place where the flat epithelial layer has been removed (f v f, hæmalum and eosin)

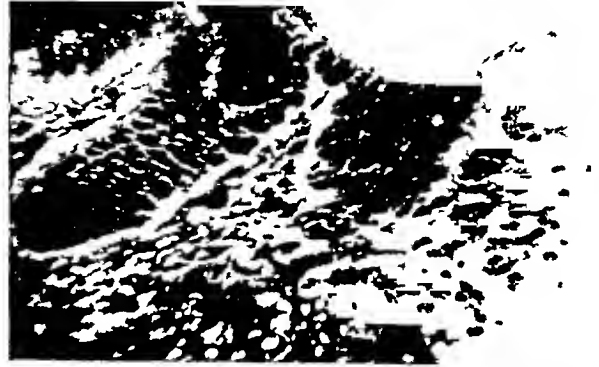


FIG 383—Micro incineration of the gastric mucosa where the layer has been removed

were rabbits, as they are constantly in use in our laboratory for diagnostic purposes.

**Stomach**—In the stomach exists a layer which comes from the upper layer of the tunica mucosa of the œsophagus and covers all the stomach, passing to the intestine (Figs 378, 379). This layer has

mucous membrane has been fixed by f v f. It is very transparent and can be sectioned. The incineration of the layer itself leaves ashes, demonstrating



Fig 384



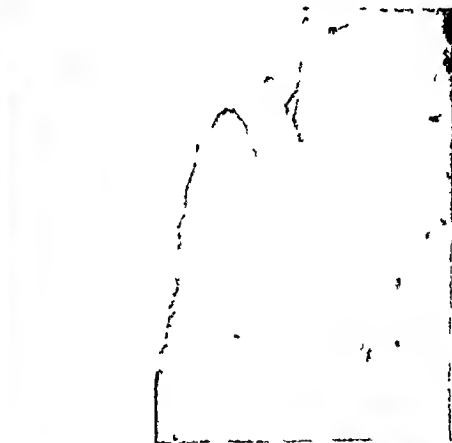
Fig 385

FIG 384—Flat epithelial layer which has been removed from the stomach shown in Fig 382 (f v f, hæmalum and eosin)

FIG 385—Micro incineration of the layer itself

been seen to cover not only the surface of the stomach but also some of the pits of the glands. Sometimes, in the same section, it can be observed how some portions are only formed by a one-cell layer, while other portions are multicellular. This layer is rich in a network of capillaries, varying in size from  $7\mu$  diameter, the size of a red blood-corpuscle, to a diameter of  $250\mu$ , which is the largest size in our collection. After micro-incineration, the layer leaves thick ashes (Figs 380-383).

The covering layer of the stomach is thicker than the layer found in the small intestine, and the



Figs 386, 387—High magnification of the covering layer and its incineration

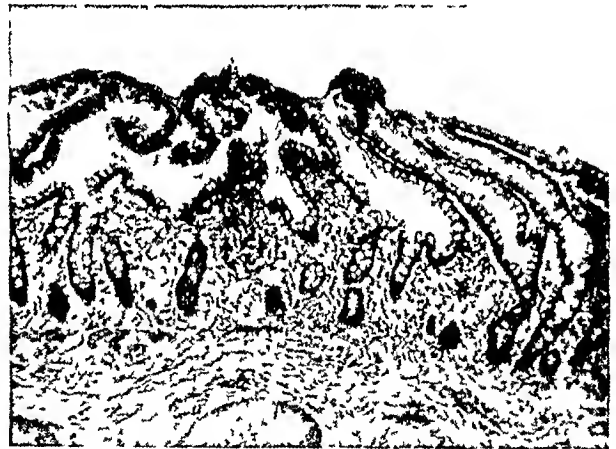
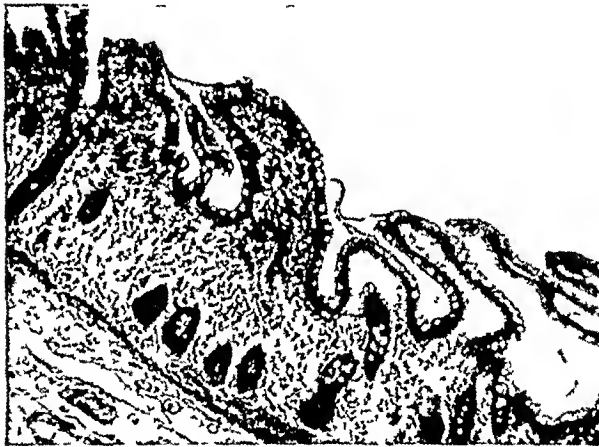
that it is not merely dried, inspissated mucous (*Figs 384-388*)



FIG 388—Stomach of rabbit showing the whole layer covering the mucosa (f v f, hæmalum and eosin)

**Small Intestine**—In the small intestine there can also be found a covering layer which is confirmed by incineration. The layer appears to be very thin and contains small capillaries. We have not been able to find any capillaries as large as the ones present in the gastric mucosa, probably because we have not had enough opportunities for studying the small intestine, as surgical specimens of this organ are scarce. The thinness of the layer can probably be attributed to the fact that in the intestine the pH of its media is in the alkaline range (*Figs 389-392*)

**Appendix**—In the appendix the covering layer shows diverse cellular contents and in some microscopical fields is monocellular. In other fields it contains a very large quantity of diapedesic cells. The existence of capillaries can also be demonstrated in this layer covering the appendix. After micro-incineration the ashes are very thick, which is in accordance with the number of cells contained in the covering layer, and the explanation for these thick ashes is quite logical when one considers that the nuclear chromatin of the diapedesic cells is very pyknotic and concentrated (*Figs 393-397*)



FIGS 389, 390—Two sections from normal intestine (f v f, hæmalum and eosin)

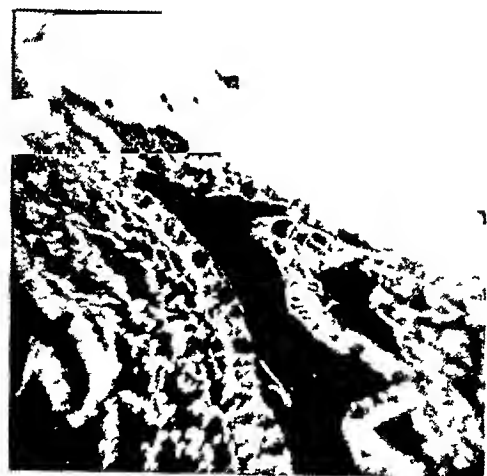


FIG 391—Details of Fig 390 under high magnification of intestine (f v f, hæmalum and eosin)  
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FIG 392—Incineration of the same field as in Fig 391

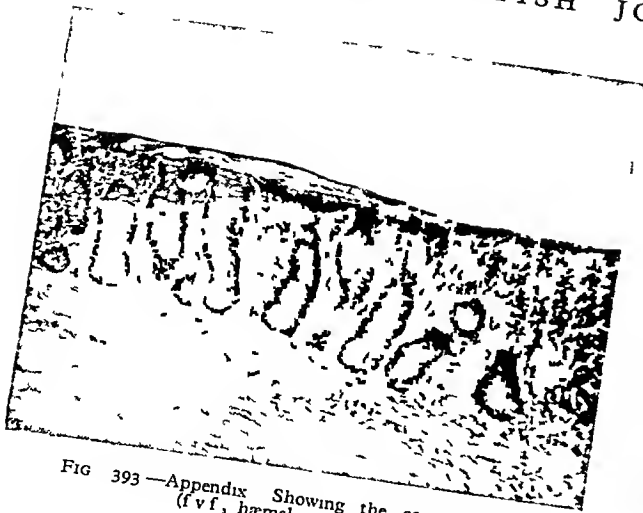


FIG 393—Appendix Showing the covering layer (f v f, hæmalum and eosin)

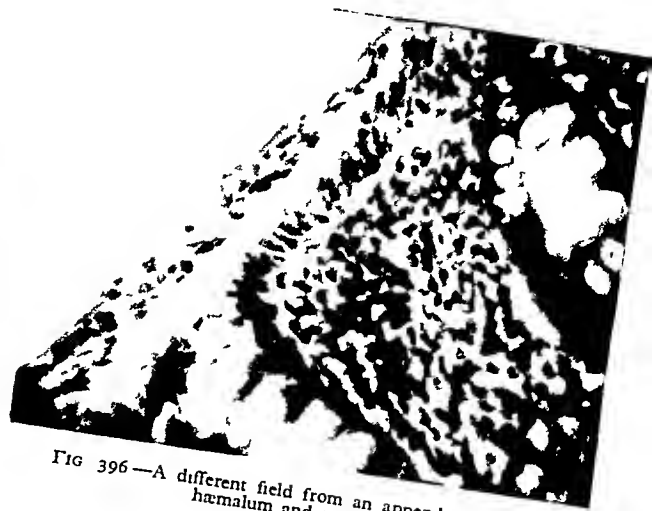


FIG 396—A different field from an appendix (f v f, hæmalum and eosin)

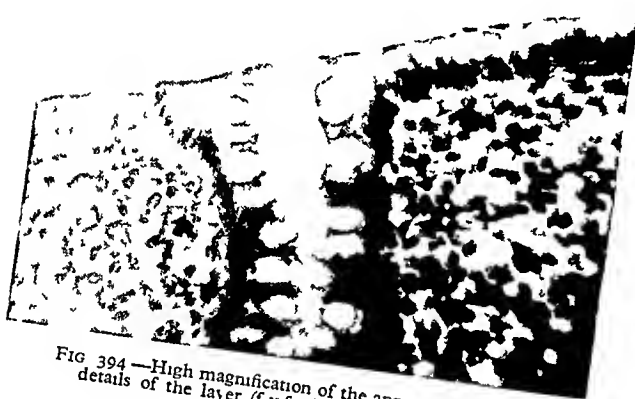


FIG 394—High magnification of the appendix showing details of the layer (f v f, hæmalum and eosin)

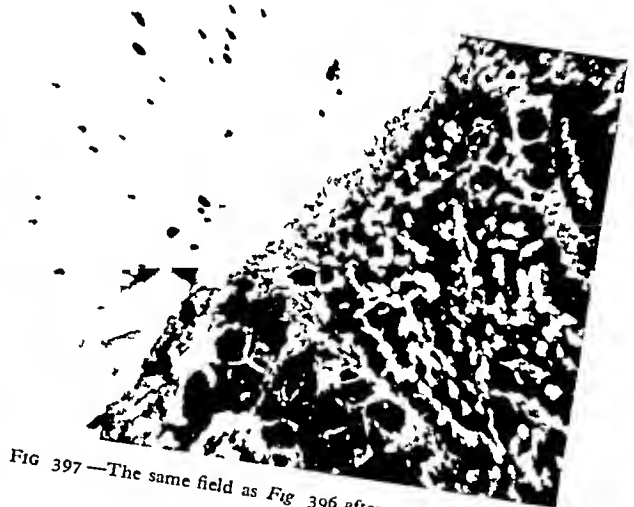


FIG 397—The same field as Fig 396 after incineration



FIG 395—The same field as Fig 394 after incineration

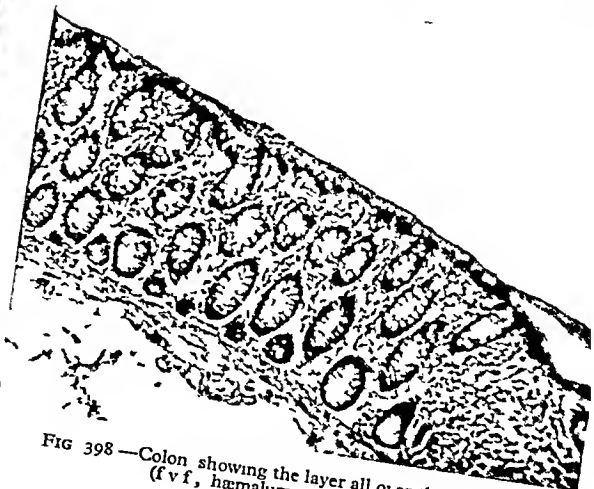


FIG 398—Colon showing the layer all over the surface (f v f, hæmalum and eosin)

**Colon**—In this organ the layer has the same appearance as the layer found in the stomach. Generally speaking, it is very thick and very vascularized, probably due to the fact that a lot of bacterial



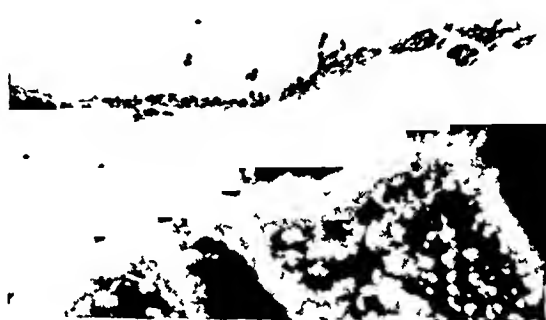
Figs 399, 400—Details of the flat epithelial layer in the colon. Note the presence of some capillaries (f v f, hæmalum and eosin)

fermentation takes place in the colon as a result of the anabolism of the hydrocarbonates present in the food remnants, and consequently the mucosa

from one organ to another and later becomes included in the stratum lucidum of the anal skin. In some of the specimens it is evident that the covering layer still contains capillaries, which are continued in the stratum lucidum of the anal skin, and this raises the question as to whether there are capillaries between the layers of the stratum lucidum and the stratum corneum in the skin, which we have demonstrated to our satisfaction and which will be published elsewhere (Figs 403, 404)

**Gall-bladder**—The layer in the gall-bladder appears to be a similar one to that found in the small intestine, and contains a few cells and small capillaries. After incineration it leaves well-marked ashes (Figs 405-407)

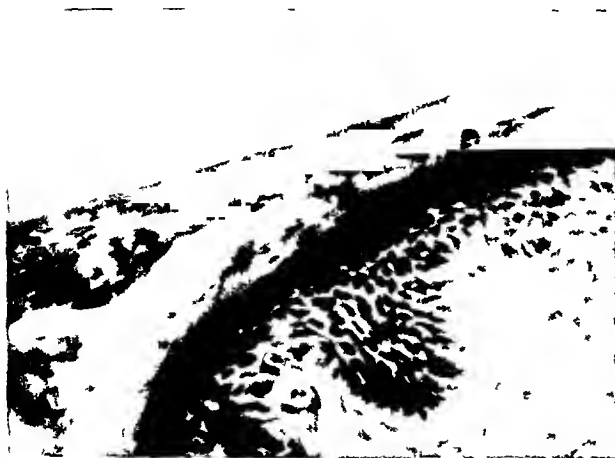
After submitting different specimens of mucous membrane from the alimentary tract to the process of micro-incineration, we are now in a position to dismiss definitely the supposition that the existence of this layer is a fake, or is the consequence of the



Figs 401, 402—Micro-incineration of the fields in Figs 399, 400

required a thick layer as a protection against the organic acids formed by bacterial and enzymatic fermentation. The ashes of this layer are also very thick, similar to the ones in the gastric mucosa (Figs 398-402)

clotting of mucus present in the gastric and intestinal tract as a result of the f v f method of fixation for the preparation of these organs. There can, therefore, be no doubt that the covering layer, which is formed by flat epithelial cells, diapedesic cells,



Figs 403, 404—The end of the layer in the stratified tissue at the junction between the rectum and anus. Notice the red blood-corpuscles included in this part of the layer (f v f, hæmalum and eosin)

**Rectum**—Following the layer from the colon mucosa to the rectum and the anal stratified squamous epithelium, it can be seen how the layer passes

and capillaries, is a genuine organic formation, which should be considered in the future study and description of the histology and pathology of the





FIG 405—Gall-bladder—showing the layer (f v f, hamalum and eosin)

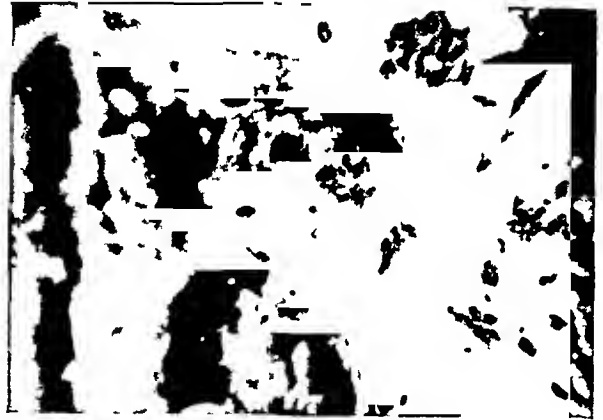


FIG 406—Micro incineration of the same field

mucous membrane of the stomach, intestines, and gall-bladder

### SUMMARY

The author has demonstrated, by using the micro-incineration technique, the organic nature of the flat epithelial layer, previously described by him, which covers the gastric and intestinal mucosæ and the gall-bladder mucosa

I would like to thank Professor Wood Jones for his great interest in this work. Also the surgeons of Ancoats Hospital, Mr P G McEvedy, Senior Surgeon, and Mr J Philp, Assistant Surgeon, for their willing co-operation in the selection of surgical specimens. I am greatly indebted to my technicians Mr C H Butcher for his help with the histological sections, and Mr J B Dean, B Sc, who has done all the photomicrographs. And in addition, I should like to give my sincere thanks to the Lay Board of this hospital who have been kind enough to supply us with the necessary equipment

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FIG 407—Incineration of another field of the gall-bladder where the ashes of the covering layer can be seen

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## METASTATIC OSTEOMYELITIS SECONDARY TO TROPICAL ULCER

BY MARGARET M SHEPHERD, MAJOR, R A M C, SURGICAL SPECIALIST

IN a series of 98 cases of tropical ulcer in Gurkha soldiers treated in the Combined Military Hospital, Dehra Dun, 11 had metastatic inflammatory lesions in one or more long bones remote from the site of the ulcer. The part of the bone initially and mainly involved, i.e., the cortex of the diaphysis, and the natural course of the disease in the bone, with invariable spontaneous cure, make this a distinctive form of osteomyelitis.

The ulcers were of the type described by Manson-Bahr as tropical sloughing phagedæna,

ulcus tropicum, Naga sore, etc. In the series of cases described they occurred on the leg or near the knee. After admission the ulcer passed, clinically, through four stages—

1 *The Stage of Spread*—Where the edges are becoming everted and spreading, and the floor is sloughy and purulent.

2 *The Stage of Liquefying Gangrene*—Here the edges are everted and sometimes 'heaped' and the floor is gangrenous—streaked with alternate blood and pus. Discharge is copious and foul smelling.



3 *The Stage of Commencing Recovery*—The purulent discharge is thicker and less copious, granulations appear in the floor, and the edges flatten

4 *The Stage of Epithelialization*—The floor is of clean granulation tissue, and epithelium grows inwards

The ulcers were treated in the first three stages by daily or twice daily cleansing by means of gently syringing the ulcer with eusol or boric lotion, and then by the application of gauze soaked in 10 per cent sodium sulphate solution. Elevation of the limb and splinting were sometimes employed. In the healing stage acriflavine and later a dilute ammoniated mercury ointment were used.

In many uncomplicated cases the four stages were achieved in about four weeks, but not infrequently cases occurred in which Stage 2 persisted for six to eight weeks. The long-standing cases often showed evidence of underlying bone reaction, and, in several instances, of bone necrosis and the separation and discharge of sequestra. It is the remote metastatic bone lesion, however, which is of more interest.

### CASE REPORTS

In the following case histories technical difficulties, shortage of films, and for one period breakdown of the X-ray apparatus prevented the taking of radiographs as often as was desirable.

Wassermann and Kahn reactions were asked for in all cases. The results are inserted here—

Case 1 Report not sent	Case 6 Negative
Case 2 Blood haemolysed	Case 7 Contaminated
Case 3 Negative	Case 8 Negative
Case 4 Negative	Case 9 Negative
Case 5 Report not sent	Case 10 Negative
	Case 11 Negative

The histories are written in weeks dating from the date of origin of the ulcer as accurately as could be ascertained from the history.

*Case 1*—Gokarna Bdr, a Gurkha, aged 21 years. Admitted Nov 5, 1943. Ulcer, said to be of fifteen days' duration, was situated about the middle of the left shin and was roughly oval in shape (2 in. × 1 in.), with a dirty sloughing floor and everted edges.

*4th week* Complained of pain on the anterior aspect of the right ankle. No fever. On examination, tenderness lower end right tibia. Ulcer clean.

*6th week* Ulcer healed. Pain middle of right leg. No fever. On examination, tender swelling of right shin. Radiograph (misplaced) showed linear periostitis and fluffy new-bone formation and decalcification of the underlying cortex about the middle third of the right tibia. White blood-count: Total leucocytes 8600.

*10th week* Pain slight. Tender diffuse swelling right shin persists.

*14th week* Almost painless. Radiograph showed woolly new bone almost the whole length of the shaft of the tibia, especially marked on the anterior and external surfaces, and some linear periosteal new bone on the proximal part of the inner surface of the shaft.

*17th week* Painless. Still slightly tender.

*19th week* Very slight tenderness. Radiograph showed increased definition and calcification of the new bone. No absorption. Appearance of the tibia like Paget's disease (Fig 408).

*20th week* No pain or tenderness.

*21st week* No alteration in palpable thickening of right tibia. Discharged to duty.

*Case 2*—Jhabal Lal Chettri, a Gurkha, aged 19. Admitted Dec 6, 1943. Ulcer, said to be of twenty-one days' duration, was situated about the middle of the left shin and was roughly oval (2½ in. × 1½ in.), with a dirty gangrenous floor and everted edges. Ingual adenitis noted. No fever.

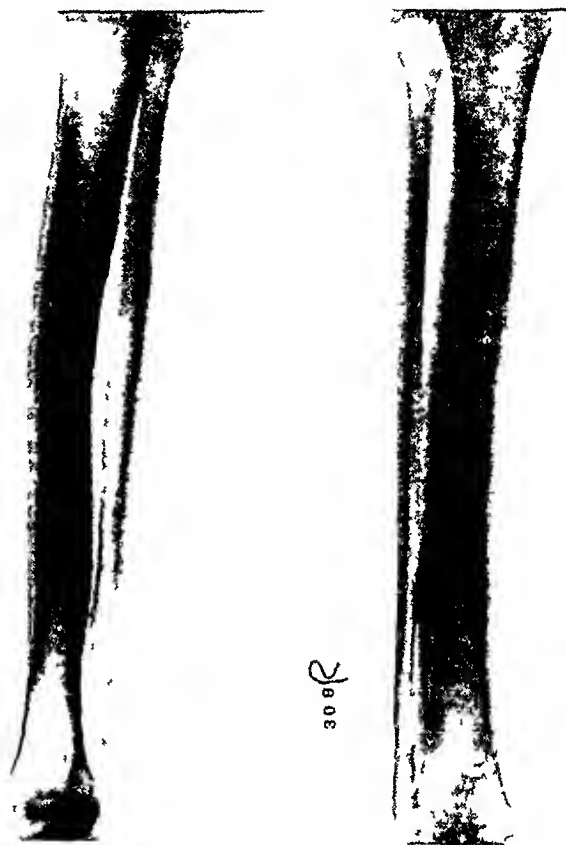


FIG 408—*Case 1* Radiograph taken at nineteenth week.

*6th week* Remittent fever up to 100° for four days. Complained of pain in both legs. Vague tenderness. The ulcer was clean. Sulphathiazole 1 g four-hourly given (up to 30 g). Some diminution of pain.

*7th week* Ulcer clean and healing. A tender swelling was noted in the left tibia distal to the ulcer, and in the lower quarter of the right fibula. On radiography, very slight decalcification in the cortex of the lower end of the shaft of the right fibula and also in the lower end of the shaft of the left tibia.

*8th week* Ulcer almost healed. Pain in legs less.

*9th week* Ulcer healed. Complained of pain in left thigh. Tenderness lower part of the shaft of left femur. Blood-count—total white cells 10,400, polymorphonuclears 61 per cent, lymphocytes 34 per cent.

*10th week* X-ray examination, cortical destruction and fluffy new-bone formation involving the lower third of the shaft of the fibula—the lower limit being 2 in. above the tip of the external malleolus. Similar appearance of left femur, involving about 5 in. of the antero-external surface of the shaft of the bone.

*11th week* No pain right fibula, but pain in left femur and left tibia. Fever intermittent up to 100° for two days. Non-tender swelling right fibula. Very tender swelling left lower femur and left tibia.

The pain and tenderness gradually settled in the left tibia, but persisted longer in a mild form in the left femur.

*17th week* No pain or tenderness in thighs or legs. Radiograph of right fibula showed increased calcification and definition of the new bone with a flattening of its

outline, though little resorption had taken place. Apparently similar changes in left tibia. Left femur showed much irregular new bone involving the shaft more extensively than on the previous X-ray examination.



FIG 409—Case 2 Radiograph taken March 9, 1944

Calcification has taken place and the appearance is not unlike that of melorheostosis (Fig 409).  
19th week Discharge to light duty

Case 3—Tilak Bdr, a Gurkha, aged 19 years. Admitted Dec 21, 1943. Ulcer, which was said to be of two months' duration, was situated about the middle of the right shin, was about  $1\frac{1}{2}$  in  $\times$   $1\frac{1}{2}$  in in size. It had a moderately dirty floor and everted edges.

9th week Complained of pain in both forearms, particularly in the right. On examination, no fever. Slight tenderness, middle right radius.

11th week Slight pain persists in the right forearm. On examination, diffuse tender swelling in right radius in the middle and lower third.

12th week Ulcer clean.

14th week Ulcer healed. X-ray examination showed osteomyelitis of the middle half of the right radius, with bone destruction and both fluffy and linear periosteal new bone (Fig 410). White blood-count—total leucocytes 10,800, polymorphonuclears 72 per cent.

18th week Pain very slight and tenderness less. Palpable thickening of both radii.

20th week No pain or tenderness. Radiograph showed some little absorption of new bone in right radius, consolidation of the remainder. Some decalcification persists (Fig 411). Left radius showed a similar appearance, although less marked.

21st week Discharged to duty.

Case 4—Bhim Bdr, a Gurkha, aged 35 years.

Admitted Aug 31, 1943, with an infected laceration in right infrapatellar region.

3rd week Noted as a tropical ulcer,  $2\frac{1}{2}$  in  $\times$   $2\frac{1}{2}$  in.

About the fifth week complained of pain in both legs and in the left clavicle.

10th week (first seen by writer). General condition poor. Pain in legs and left clavicle. On examination, tender thickening of middle left clavicle and middle of both tibiae. No fever. X-ray examination, left clavicle showed



FIG 410—Case 3 Radiograph taken Jan 22, 1944



FIG 411—Case 3 Radiograph taken March 9, 1944

# OSTEOMYELITIS FOLLOWING TROPICAL ULCER

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decalcification and infective erosion of the outer half  
A little faint new-bone formation Left tibia showed  
decalcification suggesting osteomyelitis of the lower two-  
thirds of the shaft A little faint subperiosteal new bone  
Right tibia showed similar changes in the middle and the  
upper thirds of the shaft  
11th week Fever up to 101° Blood-culture sterile  
13th week Fever continues up to 102° at night  
Sulphathiazole 1 g four-hourly Clavicle less  
14th week 24 g sulphathiazole given  
15th week Afebrile Shins less painful and tibiae  
less tender Still afebrile, but pain and tenderness in  
16th week the upper part of the shafts of both tibiae have increased  
20th week On radiography, left tibia showed increased  
bone destruction throughout the whole thickness of the  
upper part of the shaft, some periosteal new bone  
Right tibia gave a similar appearance Leucocyte count,  
15,000, polymorphonuclears, 76 per cent  
21st week No pain Thickening of tibiae persists  
No tenderness General condition has improved  
22nd week Right foot-drop developed, with blunting  
of sensation in the right anterior tibial and musculo-  
cutaneous areas of sensory supply Slight oedema both  
ankles

27th week Pain and tenderness in the right shin  
and the slight oedema persist Very slight pain and  
tenderness in left shin  
28th week No pain Slight tenderness right tibia  
No oedema  
29th week No pain or tenderness  
31st week Discharged from hospital Apart from  
recovering foot-drop, fit for work

Case 5—Chettri Bdr, a Gurkha, aged 17 years  
Admitted Nov 4, 1943, with multiple small ulcers  
on the outer side of the right leg, said to be of one month's  
duration The total ulcerated area was 3 in × 3 in and  
the ulcers had sloughy floors and everted edges  
6th week Complained of pain in the front of the  
right thigh No fever Ulcers have coalesced, but are  
clean and epithelialization has begun  
8th week Pain persists Tender thickening of the  
lower part of the femoral shaft X-ray examination  
showed linear and faint fluffy periosteal new bone around  
the whole thickness of the lower half of the shaft of the  
right femur, slight decalcification in the cortex on  
the anterior aspect of the lower shaft  
11th week Ulcers healed Pain less, but slight  
intermittent fever up to 99°  
12th week Afebrile Slight pain and tenderness  
14th week No pain Slight tenderness right  
femoral shaft  
18th week No pain No tenderness Wishes to  
be discharged, but detained for X-ray examination, etc  
Leucocyte count, 8800  
21st week X-ray examination showed consolidation  
and calcification of new bone, causing irregular thicken-  
ing of the lower half of the right femoral shaft  
23rd week Discharged to full duty

Case 6—Tanka Bdr Thapa, a Gurkha, aged 22 years  
Admitted Sept 13, 1943, with an ulcer, said to be of  
one month's duration, about the middle of the right  
shin The ulcer was 3 in × 2½ in, with everted edges  
and a gangrenous floor  
16th week Complained of pain in both thighs  
Ulcer clean and healing Febrile Evening tempera-  
ture up to 100° On examination, tender thickening,  
both femoral shafts Leucocyte count, 18,400, poly-  
morphonuclears, 82 per cent  
17th week X-ray examination of right femur showed  
cortical decalcification and erosion for 7 in of the lower  
and middle part of the shaft anteriorly, linear and fluffy  
periosteal new bone externally, internally, and anteriorly  
for 5 in or so The left femur showed similar, although  
less marked changes, in the upper half of the shaft on  
the external, internal, and posterior surfaces  
18th week Irregular fever continues, 99-101° in  
the evening Sulphathiazole 1 g four-hourly (total,  
24 g) given, on completing course the pain was less  
19th week Afebrile Still some pain in thighs  
21st week Very slight pain Tenderness persists  
23rd week No pain Very slight tenderness Ulcer  
healed  
24th week Very slight tenderness Leucocyte  
count, 7200, polymorphonuclears, 66 per cent  
26th week No pain, no tenderness Thickening of  
femoral shaft persists  
27th week Feels quite fit for duty, and appears so  
Kept in hospital for a later X-ray examination  
32nd week X-ray examination of right femur showed  
consolidation and calcification of the new bone with  
recalcification of the eroded cortex Left femur showed  
similar changes, producing irregular thickening of the  
shaft from half an inch below the lesser trochanter  
33rd week Discharged to full duty

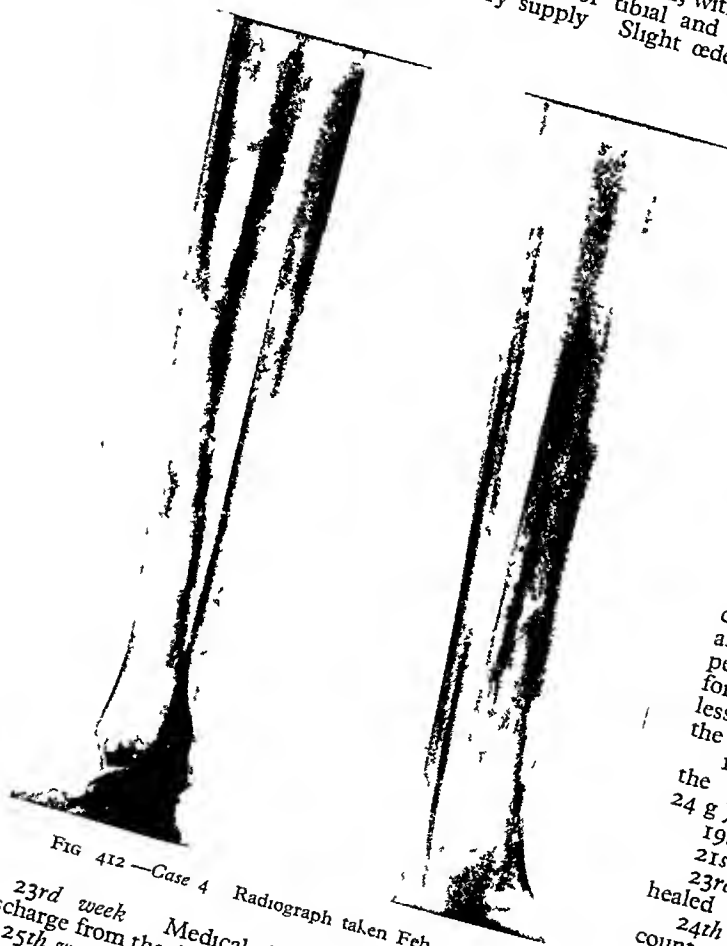


FIG 412—Case 4 Radiograph taken Feb 27, 1944

23rd week Medical board held Recommended  
discharge from the Army as unfit for further service  
25th week General condition greatly improved, still  
has slight pain and tenderness in both shins X-ray  
examination Right tibia, osteomyelitis of the upper  
part of the shaft, with fluffy periosteal new bone, and  
denser areas of old cortex, which appear to be sequestra,  
in the lower part of the shaft there is decalcification,  
erosion of cortex, and periosteal new bone Left tibia,  
very similar changes (Fig 512) Clavicle, dense bone

region It was 1 in  $\times$  1½ in and had everted edges The floor was fairly clean

7th week Complained of pain in the right thigh Some fever, evening temperature rising to 99° Tenderness mid-shaft right femur Ulcer not healing, floor more gangrenous

8th week Moderate fever continued till this week Leucocyte count near the end of febrile period, 6800, polymorphonuclears 75 per cent

X-ray examination showed linear periosteal new bone on the lateral and anterior aspects of the middle and lower parts of the shaft of the right femur Faint fluffy new bone on the anterior aspect

9th week Ulcer healed Pain and tenderness persist, but less marked

13th week No pain or tenderness

14th week X-ray examination showed consolidation of new bone, some cortical decalcification anteriorly mid-shaft

26th week Discharged to duty

Case 8—Kjs Bdr Chettri, a Gurkha, aged 17 years

Admitted Nov 12, 1943, with two ulcers said to be of thirteen weeks' duration The ulcers, each 1½ in  $\times$  1 in, were situated on the outer side of the lower third of the left leg Floors dirty and gangrenous, with some eversion of edges

24th week Complained of pain and tenderness of the whole of the inner side of the right shin No fever Ulcers cleaning No definite bone changes on radiography Leucocyte count, 10,800, polymorphonuclears, 70 per cent

25th week Middle third right tibia thickened and tender Ulcers healing

28th week X-ray examination, patchy decalcification and thickening of the cortex of the anterior part of the middle third of the right tibia

29th week No pain, no tenderness Thickening persists

31st week Discharged to duty

Case 9—Sher Bdr Ali, a Gurkha, aged 17 years

Admitted Nov 15, 1943, with ulcer, said to be of a month's duration, situated on the outer aspect of the lower third of the left leg, it measured 1½ in  $\times$  3 in, and had a dirty gangrenous floor

13th week Complained of tenderness right shin Ulcer becoming cleaner No fever

15th week X-ray examination showed small patch of decalcification in the cortex of the anterior part of the shaft of the right tibia 4½ in above the lower end Leucocyte count, 12,800, polymorphonuclears, 65 per cent

16th week Ulcer healed No pain in shin Slight tenderness Right tibia thickened and tender at the junction of the lower and middle thirds

19th week Two days' fever Tenderness less

20th week On radiography, more extensive decalcification was apparent in the anterior part of the cortex of the lower shaft of the right tibia Affected area extended for 5 in Periosteal new bone anteriorly and medially No pain or tenderness

22nd week No pain or tenderness Discharged to duty

Case 10—Tej Bdr, a Gurkha, aged 18 years

Admitted Nov 25, 1943, with ulcer, said to be of three weeks' duration, situated superficially to the left internal malleolus It was 1 in  $\times$  1½ in and had everted edges and a dirty floor

7th week Complained of pain in left mid shin No fever Tender swelling at the junction of the lower and middle thirds of the left tibia

11th week Ulcer healed Shin still tender X-ray examination On the anterior surface of the left tibia, at the junction of the lower and middle third, the cortex

for 5 in is decalcified and eroded Over 7 in of periosteal new bone, linear and fluffy, is deposited Between the new bone and eroded cortex is an apparent space

12th week Leucocyte count, 13,000, polymorphonuclear leucocytes, 75 per cent

13th week Pain slight Swelling and tenderness persist, but tenderness is decreasing

16th week X-ray examination showed recalcification and consolidation of the new bone, with resultant thickening of the shaft of the tibia The 'space' noted before is still evident

19th week Very slight pain and tenderness

20th week No pain or tenderness

21st week Discharged to duty

Case 11—Sahi Bdr, a Gurkha, aged 22 years

Admitted Nov 21, 1943, with an ulcer, said to be of two weeks' duration It was situated on the lower third of the right shin and had everted edges and a gangrenous floor Mild inguinal adenitis

6th week Ulcer still very dirty Has had intermittent fever, up to 100°, for eleven days

8th week Complained of pain in middle of the left shin No fever now Tenderness, left mid shin Ulcer still very dirty

11th week Ulcer becoming cleaner Tender swelling mid tibia (left) Fever intermittent up to 100.2° X-ray examination Decalcification of cortex and slight new-bone formation for about 5 in of the anterior surface of the shaft of the left tibia Leucocyte count, 18,000, polymorphonuclears, 64 per cent, lymphocytes, 28 per cent

13th week Fever continues Pain and tenderness continue Sulphathiazole, 1 g four-hourly, to a total of 20 g

14th week Fever settling Pain and tenderness less Ulcer still has a slough in the centre, although healing from the edges

16th week X-ray examination showed increased destructive changes and decalcification in the cortical bone for almost the whole length of the shaft These changes, as also new-bone formation, are particularly marked on the external and anterior surfaces

21st week Ulcer healed Very slight pain and tenderness

26th week No pain or tenderness

27th week Discharged to duty

## SUMMARY OF THE MAIN FEATURES OF THESE CASES

**Aetiology**—The patients were all Gurkha males undergoing training in Dehra Dun and the adjacent jungle The average age was 20 years, the youngest being 17 years old and the eldest 35 years

All cases developed the bony lesion while in hospital undergoing treatment for the ulcer, hence trauma was not a factor in the aetiology In 10 out of 11 cases (the exception being Case 11) the ulcer was clean and healing at the time of onset of the bone disease, as shown by the occurrence of pain The onset of bone pain occurred on an average four weeks before complete healing of the ulcer took place

**Clinical Course**—The first symptom of a bone being affected was local pain and tenderness The pain was not as a rule severe, the patient usually mentioned the pain four or six days after the onset In two cases only—Cases 2 and 4—did severe pain develop The mildness of pain in some cases may be illustrated by Case 3, who complained of pain in the right forearm only and hence radiographs of that limb only were taken At a

later date thickening of both radii was noticed and X rays showed almost as great an affection of the left as the right radius. Another patient, who attended the out-patient department more recently than these in this series, was sent up because he complained of pain in the left shin during P.T. He had had a small tropical ulcer near the head of the left fibula for which he had not been admitted to hospital. It had healed three weeks before the onset of the bone pain. Clinically the middle of the left tibia was thickened and tender. X rays revealed the typical cortical decalcification and fluffy new-bone formation over the middle third of the inner side of the left tibia.

In two cases—*Cases 5 and 6*—radiographs taken soon after the onset of pain showed marked changes, suggesting that when the bone was first affected there had been no pain. Tenderness persisted after all pain had subsided. Disappearance of tenderness was taken as denoting clinical cure.

In only 3 of the 11 cases, i.e., *Cases 2, 6, and 7*, did fever accompany the onset of symptoms. In *Case 2* it lasted for four days only at the time of onset, but recurred mildly for a week five weeks later. In *Case 6* fever was more marked and lasted for two and a half weeks. In *Case 7* it was mild and persisted for nearly two weeks.

Four cases (*Cases 1, 3, 8, and 10*) ran a completely afebrile course. Of the remainder *Case 9* had mild fever for two days. *Case 4* had marked fever for five weeks, *Case 5* had mild fever for one week, *Case 11* had moderate fever for four weeks. Sulphathiazole was given in *Case 4*, as he had persistent fever and his general condition was deteriorating. Some relief of pain appeared to result, and the fever was less marked, subsiding the week after the course of sulphathiazole was completed. In *Case 2*, where pain was a feature, sulphathiazole was again tried and again appeared to cause diminution of the severity of the pain. Again, in *Case 6*, fever and pain appeared favourably influenced by the same drug, and the same result was noted in the week following the completion of the course in *Case 11*.

Leucocyte counts were done, but not systematically. A moderate polymorphonuclear leucocytosis was noted in most cases during active bone disease, but the data are insufficient.

Except in *Case 4*, the constitutional upset was mild. No evidence of pyæmia, such as the formation of abscesses, was present. Even when a subcutaneous bone, such as the tibia, was involved there was no reddening of the skin or inflammatory œdema locally. The tissues outside the periosteum appeared unaffected. In no case was sequestrum and sinus formation suggested clinically.

From the first bone symptom to complete clinical healing the average time was 12 weeks—the longest being *Case 4* (23 weeks), in which a recrudescence of disease in the tibiae seemed to take place, and the shortest was *Case 8* (5 weeks), which was the mildest of the series from all aspects. Recovery in the long case (*Case 4*) was as complete as in the others.

All cases, except *Case 4*, which developed an anterior tibial neuritis, with foot-drop, returned to duty. Some were kept in hospital a week or two longer than necessary, and against the men's wishes,

for purposes of observation. As no alteration in the local thickening of the bone seemed to be taking place, they were discharged.

Radiologically the first change was a decalcification in the cortex of the diaphysis of a long bone. Then followed linear periosteal new bone deposit and a fluffy or woolly new bone having a broadly crenated outline. In some cases healing then occurred by deposition of calcium salts in the new bone. Very little resorption took place. In other cases changes indicative of osteomyelitis appeared before healing took place. In *Case 4*, where these changes were most marked, parts of the shaft appeared dense and had all the appearance radiologically of sequestra. Yet there was no attempt on the part of the body to extrude these pieces of bone. This patient was kept in hospital four weeks after complete clinical healing had taken place.

#### THE RELATION OF THE SITE OF THE BONY LESION TO THE SITE OF THE ULCER

Case No	Ulcer Site	Bone Affected
1	Left shin	Right tibia
2	Left shin	Right fibula, left femur, left tibia
3	Right shin	Both radii
4	Right infrapatellar region	Left clavicle, both tibiae
5	Right leg	Right femur
6	Right shin	Both femora
7	Left infrapatellar region	Right femur
8	Left leg	Right tibia
9	Left leg	Right tibia
10	Left internal malleolar region	Left tibia
11	Right shin	Left tibia

I have since seen 2 cases where the shaft of the humerus was involved and so far the only long bones which have not been affected have been the ulna and ribs, but it seems probable that any long bone may be attacked and the commonest are the tibia and then the femur.

The incidence of bone lesions in 11 out of 98 cases is high. At this time all tropical ulcers could not be admitted to hospital owing to shortage of beds, and thus severe or protracted cases were given preference for admission.

#### CONCLUSION

Eleven cases of inflammatory metastatic bone disease in cases of tropical ulcer have been described.

The bone lesion is unusual in that, although marked radiological changes were present, pain and general constitutional upset were not marked features. The part of the bone primarily involved was invariably the cortex of the diaphysis. In no single case was the metaphysis involved. The peculiar fluffy new bone did not absorb to any extent, and a thickening of the involved bone remained. In no case did any operative procedure appear to be indicated. All healed spontaneously.\*

Further study would seem to be indicated.

I wish to thank the radiologist, Major Eates, I.A.M.C., for his help in radiography, and Dr Sharma, C.M.P., for his great assistance in note taking.

\* Since writing the above, a few similar cases have been treated with penicillin and the results are encouraging.

## TENDON TRANSPLANTATION FOR RADIAL PARALYSIS\*

BY R B ZACHARY

MORE than a generation elapsed between the introduction of tendon transplantation for motor paralysis by Nicoladoni (1882) and its extensive use for permanent radial paralysis by Robert Jones (1917), whose technique is still widely used to-day. It consists of the transference of pronator teres into the radial extensors of the wrist, flexor carpi ulnaris into the extensors of the third, fourth, and fifth digits, and flexor carpi radialis into extensor pollicis longus and extensor indicis. At about the same time as Robert Jones described his technique Stoffel (1918) in Germany was performing a similar operation, but used flexor carpi radialis as a transplant into the radial extensors, the tendon of flexor

longus was absent, and rather than use both wrist flexors he split flexor carpi radialis into two and used one portion as transplant to the thumb and the other as transplant for the fingers. Although the earlier writers insisted on a transplant for the paralysed wrist extensors, Steindler (1940) does not advocate this procedure. He attaches flexor carpi radialis to extensor pollicis longus, palmaris longus to abductor pollicis longus, and flexor carpi ulnaris to extensor communis digitorum. Abbott (1944) reviewed the results of a series in which a slightly modified Robert Jones technique was used, pronator teres was attached to the radial extensors, flexor carpi radialis to all the extensors of the thumb and index, and flexor carpi ulnaris to the extensors of the other fingers. He found that in some cases there was powerful extension of the fingers, but in others this action was weak, and to remedy the defect a supplementary arthrodesis of the wrist was necessary. He concludes that "for those patients requiring hard usage of the wrist with complete extension of the fingers and thumb" a combined arthrodesis and tendon transplant is necessary. A summary of the various methods of tendon transplantation described above is given in Table I.

Most of the authors stress the importance of careful technique and in particular the need for correct post-operative treatment. The persistent assertion in these papers that failures were due to defective post-operative care, strongly suggests that failures are by no means uncommon. The following analysis of tendon transplants for radial paralysis, performed at the Wingfield-Morris Hospital between 1940 and 1945, was undertaken with a view to determining the reasons why some tendon transplantations are less successful than others.

## OPERATIVE AND POST-OPERATIVE TREATMENT

Although the operations were performed by different surgeons, the operative technique was the same in most respects, the principal variation being in the choice of tendons to be transplanted. The transplanted tendons were threaded through the paralysed tendons and sutured with black silk. In a few cases the tendons of the paralysed muscles were divided proximal to the site of suture to correct an extensor tendon contracture. The wrist and digits were held in extension while the suture was being performed and until a plaster cast had been applied and was firm. The wrist and metacarpophalangeal joints were maintained in extension, but the interphalangeal joints were allowed to flex to about 45°. After three weeks the plaster was removed and an anterior plaster slab applied, during the subsequent three weeks this splint was worn at night and for a variable period during the day, depending on the tightness of the transplant. Throughout this period the transplanted muscles were given faradic stimulation and voluntary exercise, and the patient was kept under close supervision.

Table I—SUMMARY OF METHODS OF TENDON TRANSPLANTATION

AUTHOR	DATE	MOTOR TENDON*	RECIPIENT TENDON
Jones	1917	PT FCU FCR	ECR ECD to 3rd, 4th and 5th digits EPL and EI
Stoffel	1918	FCR Flexor sublimis to 3rd digit FCU	ECR APL and EPB EPL and ECD
Starr	1922	(a) PT PL FCR	ECR APL, EPB, and EPL EI and ECD
		(b) PT FCR	ECR Extensors of all digits
Steindler	1940	FCR PL FCU	EPL APL and EPB ECD
Abbott	1944	PT FCR FCU	ECR Extensors of 1st and 2nd digits Extensors of 3rd, 4th, and 5th digits

\* Note. The following abbreviations will be used for the muscles of the forearm in the tables—

Pronator Teres	PT
Flexor Carpi Radialis	FCR
Flexor Carpi Ulnaris	FCU
Palmaris Longus	PL
Brachio-radialis	BR
Extensor Carpi Radialis (Longus)	ECRL
Extensor Carpi Radialis (Brevis)	ECRB
Extensor Communis Digitorum	ECD
Extensor Minimi Digiti	E Min Dig
Abductor Pollicis Longus	APL
Extensor Pollicis Brevis	EPB
Extensor Pollicis Longus	EPL
Extensor Indicis	EI

sublimis to the third digit for abductor pollicis longus and extensor pollicis brevis, and flexor carpi ulnaris for extensor pollicis longus and extensor communis digitorum. Starr (1922) was the first to suggest leaving one wrist flexor in its original place, he used flexor carpi radialis and palmaris longus to extend the digits, but did not disturb flexor carpi ulnaris. In five of his series of 43 cases of complete radial or posterior interosseous paralysis palmaris

\* From the Department of Orthopaedic Surgery, Oxford



## METHOD OF ASSESSING RESULTS

There is no generally accepted method of presenting the results of tendon transplantation, and reports of the quality of function after the operation are usually couched in terms such as good, fair, or poor, which have a variable connotation. A standard method of assessing the improvement in function after tendon transplantation is needed.

The functional deficiency in a radial paralysis is the inability to extend the wrist and digits, and the criterion of good recovery must be the return of these actions with minimal disturbance of other functions of the hand. It is not, however, necessary or even desirable to obtain full extension of the fingers when the wrist is dorsiflexed, such a position is unnatural and uncomfortable for most individuals. During the normal action of opening the clenched fist completely the wrist comes into the neutral or slightly flexed position, and the aim of the transplant must be to reproduce this action as closely as possible. It should allow full extension of the fingers with the wrist in the neutral or slightly flexed position and yet ensure active extension of the wrist when the fingers are flexed. Undesirable sequelæ of the operation would be defective flexion of the wrist or fingers.

The first important part of the examination is, therefore, an estimate of the range of extension of the fingers and thumb. Full active extension of the fingers against gravity is all that is required, incomplete extension of the fingers is a disability proportionate to the defective range. The essential range of movement of the thumb for general purposes is full extension of the digit when it lies midway between the plane of the palm and the plane of full palmar abduction. Any disability has again a direct relation to the defect in extension, but a detailed calculation of the disability is complex and it is sufficient to indicate whether extension of the thumb is full or not.

The second important assessment is the range and power of wrist extension, for good function a range of 20° is adequate, but the transplant must be strong enough to act against gravity and resistance, since on this depends the ability to lift heavy objects.

Defective flexion of the wrist can be assessed by measuring the range and power of this movement. The complete loss of the power of active flexion of the wrist is a disability of some magnitude, but if strong wrist flexion is retained, a limitation of the range of movement is of little consequence provided the neutral position can be attained. The strength of the digital flexors is not usually altered by the operation, but the range of flexion of the metacarpophalangeal joints may be limited and so contribute to a poor grip.

Examination for independent movements is principally a test of the neuromuscular control and adaptability of the patient. The fact that the patient can extend the thumb independently of the fingers does not imply independent action of the two transplants, nor does independent extension of a finger mean that one portion only of the transplanted muscle is acting. It is chiefly a matter of independent relaxation of the interossei and lumbricals.

The principal points to be considered in assessing the function of a tendon transplant can be summarized as follows —

1 Range and power of extension of fingers and thumb

2 Range and power of wrist extension

3 Range and power of wrist flexion

4 Range of flexion of fingers

When an assessment has been made according to each of these criteria it is possible to specify function as a percentage of the optimum after transplantation. Each defect is allotted an arbitrary figure, and if the total for all defects is subtracted from 100 per cent a useful index of function is obtained. The following individual assessments are made —

Defective extension of fingers	for each	10 per cent
10° short of full extension		10 " "
Defective extension of thumb		10 " "
Defective extension of wrist	inability	20 " "
to extend wrist to 20° against resistance		
Defective flexion of wrist	inability to	20 " "
flex to neutral position		
Defective flexion of fingers	slight	10 " "
	serious	20 " "

It is clear that the value of any estimate obtained in this way depends primarily on how closely the figures correspond to reality. Supplementary methods of assessment are first, determining what proportion of patients achieve full extension of the fingers and thumb and what proportion of patients can flex the wrist to the neutral position and extend it to 20° against resistance, secondly, by a series of transplants during these movements to include photographs of every case, but a number of typical examples will be presented.

## RESULTS

There were 22 cases of posterior interosseous paralysis and 35 of complete radial palsy. In four of the latter the wrist was arthrodosed, this group will be considered later. In the remaining 31 cases of complete radial paralysis, pronator teres was transplanted into the wrist extensors and 29 patients could extend the wrist to 20° against gravity and resistance, although in three the power of the transplant was significantly weak—3½\*. In all respects other than restoration of wrist extension, the complete radial paralysis and the posterior interosseous paralysis present similar problems—namely, the return of extension of the digits while preserving flexion of the wrist and fingers. The results will be presented in two main groups (a) Those in which both wrist flexors were transplanted, and (b) Those in which one wrist flexor only was used. These two groups, comprising 53 cases, will be considered first.

**a Both Wrist Flexors Transplanted.**—In 24 cases both flexor carpi radialis and flexor carpi ulnaris were transplanted into the extensors of the digits. In Cases 1–5 (Table II) palmaris longus was absent and the results were deplorable. Not one

\* The method of grading muscle power is that recommended by the Medical Research Council: 0 = complete paralysis, 1 = flicker of voluntary action, 2 = voluntary action sufficient to move the joint, 3 = action against gravity, 4 = action against gravity and resistance, 5 = full power.

of the patients could actively flex the wrist to the neutral position nor extend the thumb or fingers completely. The defective range of extension of the fingers varied between  $30^\circ$  and  $60^\circ$ . Yet, when the wrist was passively maintained in a neutral position, full active extension of the fingers was possible. There was thus no doubt that the transplant had been performed under adequate tension and that it would function satisfactorily if the wrist could be maintained in the position it normally occupies during the movement. The results, expressed as a percentage, vary between 10 per cent and 40 per cent, with an average of 26 per cent.

In Cases 6-24 (*Table III*), palmaris longus was present and was left in position. Although the results are better than those in *Table II*, many are not satisfactory. In 14 patients out of 19 the defective range of extension of the metacarpophalangeal joints was more than  $10^\circ$ , and in 5 patients it was more than  $40^\circ$ . In 15 cases the range of extension of the thumb was defective. Eight patients could not flex the wrist to the neutral position. The percentage grading of function varies between 20 per cent and 90 per cent, with an average of 57 per cent. The combined results in these 24 cases in which both wrist flexors were transplanted average 50 per cent, with a standard error of  $\pm 50$ .

**b Only One Wrist Flexor Transplanted**—In the remaining 29 patients flexor carpi radialis was left in situ (*Table IV*). Flexor carpi ulnaris was used as motor tendon to the extensors of the fingers in all cases except one—where extensor carpi radialis longus was employed. The transplant to the thumb extensor varied in 5 cases brachioradialis was used and in 2 an active wrist extensor in 12 patients in whom palmaris longus was present this tendon was used for extension of the thumb, but 9 patients had no palmaris longus, and for them flexor carpi ulnaris was transplanted to the thumb extensors as well as those of the fingers.

Twenty-seven out of 29 patients could extend the fingers to the neutral position, 18 patients could extend the thumb completely, and all could flex the wrist strongly to the neutral position. In one patient flexion of the index was limited. The functional result expressed as a percentage varied between 70 per cent and 100 per cent, with an average of 91 per cent and a standard error of  $\pm 14$ . The difference between this figure and the result of 50 per cent for the previous group of cases is almost eight times the standard error and is therefore unlikely to be due to chance.

The comparison of the results in the two groups is shown in another way in *Table V*. In only 21 per cent of those cases in which both wrist flexors were transplanted was almost full extension of the fingers possible, compared with 97 per cent of those in which only one wrist flexor was used. Of the former group 46 per cent could flex the wrist to the neutral position compared with 100 per cent of the latter. Although there was not such a marked contrast in the range of extension of the thumb in the two groups of cases, the difference between 16.5 per cent in the former and 69 per cent in the latter is far more than twice the standard error and therefore must be regarded as of considerable significance.

*Table II*—SUMMARY OF RESULTS WHEN BOTH WRIST FLEXORS WERE TRANSPLANTED, BUT PALMARIS LONGUS WAS ABSENT

RESULTS														
No	File No	TRANSPLANT		REMAINING WRIST STABILIZER	EXTENSION OF WRIST		FLEXION OF WRIST		EXTENSION OF THUMB		EXTENSION OF FINGERS		FUNCTION EXPRESSED AS PERCENTAGE	COMMENT
		Motor Tendon	Recipient Digit		Range in Degrees	Power	Range in Degrees	Power	Range in Degrees	Power	Range in Degrees	Power		
1	W 80	FCR FCU	1-2 2-5	None	-	-	Nil	Nil	Limited	4	60	4½	10	Improved by fixation of wrist
2	M 44	PT FCR FCU	ECR 1-2 3-5	None	30-60	4	Nil	Nil	Limited	3½	50	3½	20	Needs fixation
3	M 42	PT FCR FCU	ECR 1-2 3-5	None	10-40	4	Nil	Nil	Limited	4	40	4	30	
4	G 15	PT FCR FCU	ECR 1-2 3-5	None	40-60	3½	Nil	Nil	Limited	2½	40	4	30	Cannot let go
5	M 14	PT FCR FCU	ECR I 2-5	None	30-60	5	Nil	Nil	Limited	5	30	5	40	Desires fixation

\* The figures indicate the number of degrees short of full extension

Table V—COMPARISON OF RESULTS IN Tables II-IV

	EXTENSION OF M P JOINTS TO 10°		FLEXION OF WRIST TO NEUTRAL		FLEXION OF WRIST TO 20		FULL EXTENSION OF THUMB		TOTAL NO OF CASES
	No of Cases	Percentage	No of Cases	Percentage	No of Cases	Percentage	No of Cases	Percentage	
a Both wrist flexors transplanted	5	21	11	46	7	29	4	16.5	24
b One wrist flexor transplanted	28	97	29	100	20	69	18	62	29

Table VI—RESULTS AFTER FIXATION OF WRIST

No	FILE No	TRANSPLANT		REMAINING WRIST STABILIZER	RESULTS						COMMENT
		Motor Tendon	Recipient Digit		EXTENSION OF THUMB		EXTENSION OF FINGERS		FUNCTION EXPRESSED AS PERCENTAGE		
					Range in Degrees	Power	Range in Degrees*	Power			
54	C 25	PL FCU	1 2-5	Arthrodesis	Full	3 <sup>1</sup>	30	3 <sup>1</sup>	70		
55	E 30	PL FCR	1 2-5	Tenodesis failed Arthrodesis	Limited	3 <sup>1</sup>	20	4	70	Tenodesis a failure—wrist arthrodesed	
56	H 58	PL FCR	1 2-5	Arthrodesis	Nil	Nil	Nil	Nil	Nil	Post-operative hematoma and adhesions The transplanted muscles were not strong	
57	B 63a	FCR FCU	1 2-5	Arthrodesis	Full	4	Full	4	100		

\* The figures indicate the number of degrees short of full extension

The adverse effect of transplanting both wrist flexors is illustrated in the series of photographs. In Figs. 413-416 both wrist flexors were used and

the fingers. In Figs. 421-427 are shown those cases in which flexor carpi radialis was left in situ. It is at once evident that extension of the fingers is



FIG 413—Case 2 Palmaris longus absent, both wrist flexors transplanted. Attempted extension of fingers and thumb. Note the marked dorsiflexion of the wrist and incomplete extension of the metacarpo-phalangeal joints.



FIG 414—Case 2 Extension of fingers improved if dorsiflexion of wrist is prevented.

palmaris longus was absent the dorsiflexion of the wrist which accompanies the attempt to extend the fingers is well illustrated, and passively maintaining the wrist in the neutral position allows active extension of the fingers to take place. In Figs. 417-420 palmaris longus was present and in the first picture it appears to stabilize the wrist fairly well and permit satisfactory extension of the fingers. In Figs. 418 and 419 it is seen to be less effective and does not prevent hyperextension of the wrist, and Fig. 420 shows that adequate support for the wrist to prevent this excessive dorsiflexion permits full extension of

more complete in this series and strong wrist flexion is preserved (Figs. 422 and 426). Fig. 427 shows the effect of transplanting flexor carpi ulnaris into the fingers and thumb in a patient who had no palmaris longus. Satisfactory extension of all digits is obtained and the wrist remains in the natural position during the movement.

c Fixation of Wrist—In 4 patients the wrist was fixed (Table VI)—in 3 by operation, and in 1 by trauma. One was a complete failure in which weak muscles had been transplanted and a post-operative hematoma led to adhesions.



FIG 415—Case 1. Palmaris longus absent, both wrist flexors transplanted. Attempted extension of fingers and thumb. Note the marked dorsiflexion of the wrist and incomplete extension of the metacarpo phalangeal joints.



FIG 416—Case 1. Extension of fingers improved if dorsiflexion of wrist is prevented.

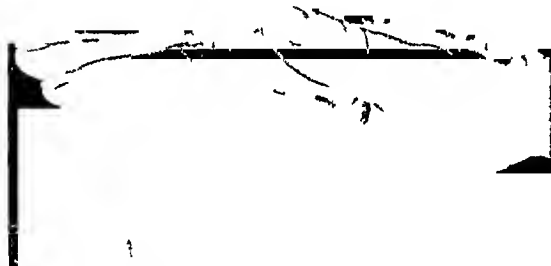


FIG 417—Case 22. Palmaris longus present, both wrist flexors transplanted. Almost full extension of fingers.



FIG 419—Case 12. Palmaris longus present, both wrist flexors transplanted. Incomplete extension of fingers and marked dorsiflexion of wrist.



FIG 418—Case 7. Palmaris longus present, both wrist flexors transplanted. Incomplete extension of fingers and marked dorsiflexion of wrist.



FIG 420—Case 12. Almost complete extension of fingers if dorsiflexion of wrist is prevented.

In two patients extension of the fingers was limited by  $20^{\circ}$  and  $30^{\circ}$ , but in one a full range was possible. Two of the three had full extension of the thumb.

## DISCUSSION

There are two important questions to be considered in the choice of tendon for transplantation.

(1) How closely can the transplanted muscle simulate

the action of the paralysed one? (2) Will the transference of the tendon cause undesirable sequelae?

1 The ability of a muscle to take over the action of another depends on its strength, its range of contraction, and the possibility of re-education.

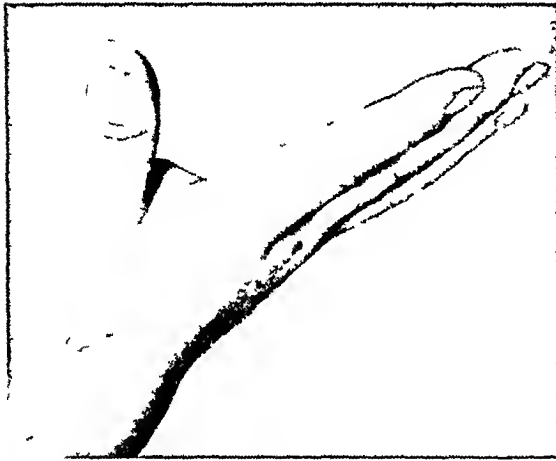
a The strength of a normal muscle depends on the number and obliquity of the muscle-fibres. The greater their number and the smaller the angle they make with the tendon, the greater will be the power.



FIG 421—Case 44. Palmaris longus present, one wrist flexor transplanted. Complete extension of fingers and thumb



FIG 422—Case 44. Strong flexion of wrist against resistance, showing flexor carpi radialis and palmaris longus in situ



FIGS 423, 424—Case 51. Palmaris longus present, one wrist flexor transplanted. Complete extension of fingers and almost complete extension of thumb

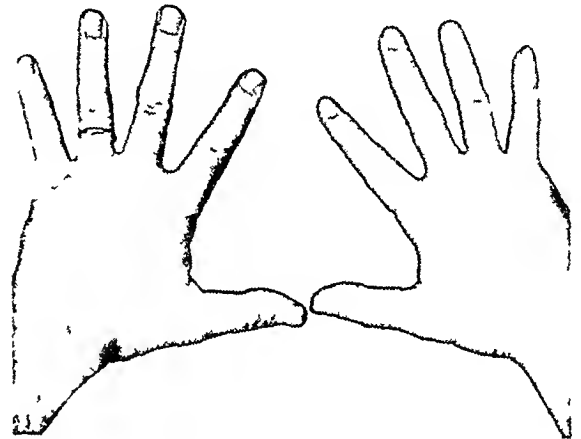


FIG 425—Case 46. Palmaris longus present, one wrist flexor transplanted. Complete extension of fingers and thumb



FIG 426—Case 46. Strong wrist flexion against resistance

*b* The range of action depends on the length and direction of the muscle-fibres and the direction of pull of the transplanted tendon. The shorter the fibre and the greater the angle it makes with the tendon, the smaller will be the range of movement of the tendon. The greater the angle at which the transplant joins the paralysed tendon, the smaller the range of action. Conversely, the longer the

fibres, the more longitudinally they run, and the more closely the motor and paralysed tendons run parallel, the greater will be the range of action.

*c* In a review dealing with nerve and muscle transposition, Sperry (1944) quotes a number of reports of failures of transplantation when antagonistic muscles were used. There is, however, ample evidence that the wrist flexors can take over the

action of muscles to which they are synergists—the extensors of the fingers—but we do not know with what facility or how completely the necessary re-adaptation may be attained. However, in two of the cases reported above, flexor carpi ulnaris had become so thoroughly re-educated that six weeks after transplantation the electromyographic recording from this muscle showed no action potentials during active flexion of the wrist. Since such a complete change of action is possible it seems unlikely that the partial readjustment of a synergist will present any difficulties.

2 The transference of pronator teres into the wrist extensors may cause a little limitation of supination of the forearm, but the muscle still maintains a powerful pronating action. It is a different matter with the wrist flexors. If palmaris



FIG 427—Case 48. Palmaris longus absent, one wrist flexor transplanted into all digits. Full extension of fingers and thumb.

longus is absent, the loss of both wrist flexors is serious. During the attempt to extend the fingers the transplanted tendons, passing behind the wrist and being unopposed, are bound to extend it. A transplanted muscle, like any other, has only a limited range of action and on account of the obliquity of its course its range is diminished, if the length of contraction of the fibres is used up in extending the wrist, there will be little left to extend the digits. This is the explanation of the defective range of extension in several cases in which both flexor carpi radialis and flexor carpi ulnaris were used as transplants.

It is sometimes contended that the long flexors of the fingers can act as flexors of the wrist and that with re-education the control of the wrist should be satisfactory. It is certainly true that the finger flexors may flex the wrist at the same time as they flex the fingers, but it is equally clear that they will be unable to perform this function at the same time as the fingers are extended, since the finger flexors are reciprocally relaxed during this action. The absence of the wrist flexors leads to excessive dorsiflexion of the wrist when the patient attempts to extend the fingers, when such a transplant is performed it is just possible to obtain full extension

of the metacarpo-phalangeal joints in spite of the unnatural position of the wrist—but only by performing the operation under such tension that flexion of the wrist and fingers is grossly limited.

Clearly, then, it is desirable to retain a wrist flexor. If palmaris longus is absent, only flexor carpi ulnaris can be spared for transplantation, unless the wrist is controlled in some other way, e.g., by arthrodesis. In the case of a posterior interosseous paralysis there are sufficient tendons available without removing a second wrist flexor, but in a complete radial paralysis the only alternative to arthrodesis of the wrist is to use flexor carpi ulnaris as transplant to all the digits. This has been shown to be satisfactory.

If palmaris longus is present the choice lies between this tendon and flexor carpi radialis as transplant. It has been demonstrated that, even when palmaris longus was left behind, the control of the wrist was not always effective and full extension of the fingers was not invariable. Flexor carpi radialis always controlled the wrist effectively enough to permit complete or almost complete extension of the metacarpo-phalangeal joints, and, moreover, preserved strong wrist flexion to the neutral position or further.

## CONCLUSION

In tendon transplantation for radial paralysis it is important to preserve an active wrist flexor to stabilize the wrist. The neglect of this precaution often leads to incomplete extension of the fingers and unnecessarily weakens or abolishes the power of wrist flexion. If flexor carpi radialis is left in situ these sequelæ seldom arise.

## SUMMARY

1 A standard method of assessing the results of tendon transplantation for radial paralysis is suggested.

2 The results of tendon transplantation are described in 57 cases of radial paralysis.

3 Better results were obtained by transplanting only one wrist flexor, flexor carpi ulnaris, and leaving flexor carpi radialis in situ.

My thanks are due to Professor H. J. Seddon for his valuable advice in the preparation of this manuscript.

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## A CASE OF SEVERE ELECTRIC BURNS WITH AN UNUSUAL SEQUENCE OF COMPLICATIONS

By JULIAN SMITH, LT-COL, A A M C, AND B K RANK, LT-COL, A A M C

A COMPLETE record of the clinical details and investigations concerning the case of one, L A C T H Van A, aged 18, of the R A A F, would be tiresome if presented *in extenso*. The following extract, prolonged as it may appear, contains its salient features only, and we will not repeat in the text those details which are graphically shown in Fig 428

His general condition continued to be grave. Blood examination revealed 3,500,000 red cells per c mm, hæmoglobin 69 per cent, hæmatocrit 30 per cent, plasma-protein 6.5 per cent. He had had 5 litres of serum since the injury. Blood transfusion was now commenced.

The lad, by this time, had survived for two days. All efforts had so far been directed to providing the usual restorative measures which abundant laboratory

### CLINICAL CHART LAC VAN ALKENADE 157261

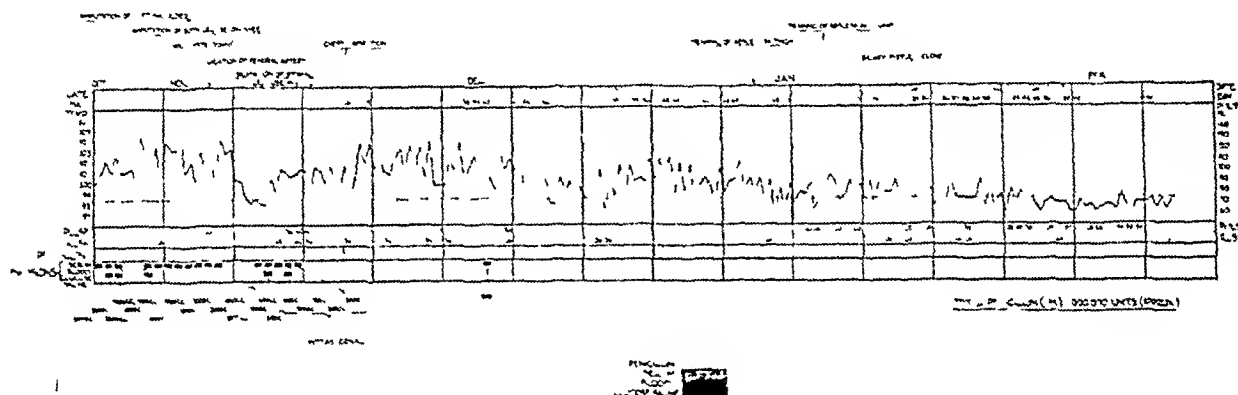


FIG 428—Reproduction of clinical chart—temperature, pulse, respiration, record of penicillin therapy, and transfusions

### CASE REPORT

Oct 23, 1944. At 17.00 hr L A C Van A was one of two survivors when a mobile crane on which he was working fouled high-tension electric wires. In the flash, he was thrown some distance, and it was immediately obvious that he had sustained burns to both lower limbs and the left arm.

He was taken to No 2 R A A F Hospital. On admission, the clinical notes stated "pulse 120, moaning and restless. Right foot cold and indurated, with burns extending to the knee. Left foot indurated with exposed and charred metatarsals. Left arm white and indurated up to the shoulder—several phalanges of the hand exposed and charred."

Five hours after the accident, infusion of serum was commenced, and under general anaesthesia the burnt areas were cleansed and dressed.

2nd day. He was transferred to No 2 Plastic Surgery Unit (on the advice of W/Cdr Searby), as it was considered that a radical excision of the burnt areas of skin with replacement might have been feasible.

At this time—17 hours after the injury—the pulse was 140, weak but regular. Blood-pressure 110 systolic. Muttering delirium. Hæmoglobin 105 per cent, hæmatocrit 51 per cent, plasma-protein 7.2 per cent.

On inspection of the burnt areas, it was apparent that both feet were lifeless, the soft tissues being either charred or coagulated. On the right leg, second-degree burns extended above this level to the knee. The left upper extremity was completely mummified, except for an area of skin over the deltoid region.

investigations indicated were expedient. At this juncture we felt that, despite adequate resuscitation, recovery could not be expected if the large areas of dead tissue in the extremities were allowed to remain.

FIRST OPERATION—Under nitrous-oxide anaesthesia, the left arm was removed through the shoulder-joint. Nerve-trunks were injected with novocain. The available deltoid flap was used to cover the defect and a tube was left *in situ* for penicillin instillation. The amputated limb is illustrated in Fig 429.

At operation, deep coagulation of the tissues was demonstrated up to the level of amputation. There was extreme oedema and reaction about the shoulder.

3rd day. By this time he had been given 3 litres of blood. Red blood-cells 4,200,000, hæmoglobin 80 per cent, hæmatocrit 39 per cent, plasma-protein 6.5 per cent. Glucose-saline infusion was therefore substituted.

6th day. Despite the fact that he had withstood the first operation as well as could be expected, his general condition was deteriorating. Both legs were offensive.

SECOND OPERATION—Under cyclopropane anaesthesia, the left leg was amputated through the level of the skin loss, the flaps being

the bone ends and drain tubes inserted. The right leg was amputated at a higher level, and in order to conserve adequate length of limb for a below-knee prosthesis, the stump included areas of burnt, but not dead, skin. Flaps were also loosely sutured and drains and tubes for penicillin inserted.

At this stage, our slight feelings of optimism engendered by the return, for the first time, of the lad's mental

faculties, were rudely dispersed by a severe epistaxis and the onset of abdominal pain

8th day General condition poor. Complaining of severe abdominal pain, colicky in nature, felt in the right lower abdomen. It was accompanied by diarrhoea and

On the microscopical sections of the gall-bladder the pathologist reported "Coagulative necrosis has occurred, involving the whole thickness of the wall at one place, and the mucosa and submucosa only at others. The rest of the tissue shows evidence of severe inflammation



FIG 429—Photographs of the left arm immediately after amputation, showing the typical admixture of clots and coagulation of the skin and tissues. Note the exposed bone

vomiting. The right upper abdomen was tender and rigid. The possibility of acute peptic ulcer with perforation was considered.

By this time decisions were becoming momentous. Here was a frail lad of 18 years of age, who for eight days had survived an injury severe enough to kill, who had suffered a triple amputation, and who now had developed an acute abdomen.

When, after some hours, a mass became evident in the right hypochondrium, the indication for operation was abundantly clear.

THIRD OPERATION—Under local anaesthesia, a right upper paramedian incision was made, and the abdominal cavity opened. There was a fair amount of fluid and

with much fibrinous exudation, hæmorrhage into the tissues, and accumulation of polymorphs."

Immediately after the abdominal section, blood transfusion was commenced via the saphenous vein in the right thigh. There was little improvement in his general condition—indeed, none could be expected. The abdomen was slightly distended and he was passing frequent small motions. There was free and foul-smelling purulent discharge from both leg amputation stumps.

12th day At 08 00 hr six days after the lower limb amputations, there was a vigorous secondary hæmorrhage from the stump of the left leg, controllable only by tourniquet. This complication was not unexpected.

FOURTH OPERATION—Under cyclopropane anaesthesia, the amputation stump was opened, clot removed, but no bleeding point could be found. The femoral artery was ligated in Hunter's canal, and blood transfusion recommenced in the right arm.

14th day Free drainage of bile from the abdominal wound continued. All amputation stumps were discharging freely and culture showed—"Leg stump *Bact coli*, *Ps pyocyanea*, *Proteus morgani*. L arm *Bact coli*, *Ps pyocyanea*, *Proteus vulgaris*, hæmolytic *Staph aureus*, green zone streptococci."

The leg stumps were suspended in Thomas splints and continuous irrigation with Eusol arranged to alternate with hypertonic saline.

17th day General condition very poor. The diarrhoea had ceased, but was replaced by copious vomiting. A stomach tube was inserted. Intravenous serum was again instituted by way of a vein on the dorsum of the right hand.

Continuation of intravenous therapy was now a problem because he was suffering gross fluid loss. The right arm was very swollen and œdematous. All available arm veins had been used, as had both sphenous veins in the upper thighs. Sternal puncture was therefore performed and glucose-saline given. Aspiration of the stomach continued to yield large quantities of fluid. The sternal drip continued to run satisfactorily after four days.

21st day Coughing up blood-stained sputum. Radiography revealed bilateral pneumonia which had been suggested by clinical signs. Happily, at this time, we were able to dispense with the gastric suction.



FIG 430—Coloured reproduction of the gall bladder as it appeared after removal. Note three separate infarcts, the large one involving the full thickness of the gall bladder wall.

exudate surrounding a large distended gall-bladder, the fundus of which included multiple gangrenous areas. Dark, thick bile was aspirated and a partial cholecystectomy performed. A tube was sutured into the remaining part of the viscus. A second tube was lead into Morison's pouch via a stab wound in the flank. The abdomen was closed in layers.

The specimen is reproduced in Fig 430.

# A CASE OF SEVERE ELECTRIC BURNS

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Dyspnoea, however, became more marked, and both pleural cavities were aspirated—the right side yielding 50 oz of blood-stained fluid, the left side 18 oz. Chest aspiration was continued twice daily. The fluid remained straw-coloured and contained blood-cells and leucocytes. Cultures of repeated specimens revealed no growth.

24th day For the first time, a decided general improvement could be noticed. The vomiting had ceased. The abdomen was satisfactory, although the biliary fistula persisted with copious discharge. Chest aspirations yielded similar fluid, but in decreasing amounts. There was a heavy Gram-negative infection of all wounds. Intravenous therapy had been suspended during the next three weeks the general condition slowly improved, although the temperature chart remained ugly. The lad had innumerable routine examinations and special investigations referable to all systems, in an effort to determine the cause of the persistent high fever. He was seen by many specialists and consultants. Blood-cultures repeatedly showed "no growth." He was given additional blood transfusions and no end of medicinal and dietetic therapy.

66th day A diffuse flat indurated mass in the left trochanteric region was noted in a routine examination under anaesthesia, the swelling was needled and a small amount of very thick pus obtained. Through a lateral thigh incision, deep to the fascia femoris, a large loculated collection of pus about the femur was displayed, and 1½ pints evacuated. Culture yielded a pure growth of *B. coli*.

73rd day Low-grade cellulitis with deep induration was noticed in the left leg stump.

SIXTH OPERATION—Under gas anaesthesia the stump was incised and a deep collection of pus was evacuated. After these two abscesses had been drained the temperature gradually fell to normal.

Three months after the accident he was sitting up in a chair. His weight was 6 st 10 lb. The biliary fistula finally closed. Radiography of chest was clear. There was a small sinus in the shoulder stump, but the leg stumps had healed after a small sequestrum had been removed from the right leg stump.

He was measured for his artificial legs, and transferred to No. 2 R A A F Con. Depot, Warburton. During his month's convalescence he had periods of marked depression, and a further exacerbation of low-grade infection with abscess formation in the shoulder wound. He returned to hospital and was fitted with his artificial legs, which he managed very well right from the start.

Finally, he was discharged (Fig 431) in very good general condition, and maintaining a philosophic attitude with regard to the loss of his limbs which was admirable. He regards himself as happily placed in the Repair Department of the State Electricity Commission, where he is a switchboard operator.

## DISCUSSION

1 *Triple amputation of limbs for severe electric burn* The value of early local excision for electric burns, in view of their depth and localized nature, is well recognized and widely practised. Extension of this principle to the degree of amputating three limbs for an extreme degree of electro-coagulation cannot be common. The course followed in this case was dictated by surgical necessity.

2 *The problem of fluid infusion* In this case, where we were denied the use of both legs and an upper extremity, the maintenance of adequate infusions was indeed a problem. This lad had an almost continuous series of blood, serum, and glucose-saline infusions over a period of 21 days. When, at his most critical stage, all the usual channels

in the remaining limb parts had been exhausted, the use of a continuous intrasternal drip for 4 days, during the period of acute dilatation of the stomach, was able to maintain his fluid balance. This *per se* was a life-saving measure. We would therefore suggest that in any case where infusions are likely to be multiple or protracted it is wise to select veins



FIG 431—Patient on discharge from hospital, 7 months after the injury

systematically. Main venous trunks should not be used and occluded early in the programme. When confronted with this problem, the sternal route—at least for glucose-saline—is most valuable.

3 *The gall-bladder complication* That such a lesion of the gall-bladder can occur as a complication of burns may in itself be worthy of record. After searching the literature we have been unable to find a case of such a complication following burns of this type. The discrete appearance of the three gangrenous patches (see Fig 430) would suggest an embolic basis for the condition. It would seem that such patches are of similar origin and nature to the so-called Curling's ulcer of the duodenum which is encountered more commonly as a complication of burns. The common basic blood-supply of the gall-bladder and duodenum may be significant.

4 *The aborted empyema* The transient nature of the severe pulmonary complication and the fact that the pleural exudate remained sterile throughout, must be attributed to penicillin.

5 *The silent abscess* This case occurred in the early days of penicillin therapy when its use was

perforce somewhat restricted. Parenteral penicillin was not commenced until the upper limb amputation was performed, but it was thereafter continued 3-hourly (with one short break) for 5 weeks.

Considering the large number of injections, the low ebb of the lad's vitality, and the multiplicity of his infected wounds, we were not unduly concerned when he developed an abscess at one of the injection sites, although it must be assumed that the infection was introduced. This complication, censurable under ordinary circumstances, was a triviality compared with the big issue at stake. The loculation and inspissated nature of pus in this abscess pointed to its long duration. It was certainly the cause of the persistent pyrexia during the latter part of this stormy passage.

6 *The result* This lad's survival was not a tribute to any one factor. Thirty-four litres of saline, serum, and blood infusions, more than 5,000,000 units of penicillin, the highest standard of excellence in nursing, expert anaesthesia, some competent surgery, perhaps, and most certainly the fighting spirit of the lad himself—all played their part and contributed to his recovery. However, none of these factors could become contributors to the happy outcome, without the binding influence of surgical pertinacity, the will to 'go for' a result, and to shun any attitude of fatalism.

Faced now with an ardent young man, interested in all that a lad of eighteen should be, with his eyesight, his right hand, and his self-respect, we are obliged to forget the chides of many—"Thou shalt not strive officiously to keep alive."

### SUMMARY

1 The salient features of a case of severe electro-coagulation burns treated by multiple amputation and followed by uncommon complications, with ultimate survival, is given.

2 Various features of this case are discussed *seriatim* the triple amputation, the problem of fluid infusion, the gall-bladder complication, the aborted empyema, the silent abscess, and the ultimate result.

Though fully implied in the results obtained, we wish to acknowledge the order of work done by all the staff of the No 2 Faeco-maxillary and Plastic Surgery Unit in the difficult surgical management and the meticulous nursing of the case.

The illustrations are the work of Flight Officer Alldritt, artist, and Cpl Hale, photographer, of this unit.

The permission of Director-General, Medical Services, Royal Australian Air Force, Air Vice-Marshal T E V Hurley, to publish this report is acknowledged.

## THREE CASES OF FRACTURE-DISLOCATION OF THE HIP OCCURRING SIMULTANEOUSLY IN ONE CAR ACCIDENT

By J C F LLOYD WILLIAMSON, LIEUT-COLONEL, R A M C

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THE hip is a strong joint and not dislocated without considerable force applied in the right direction with the thigh in a given position. Not long ago traumatic dislocation of this joint was relatively rare, but the increase in volume and speed of motoring in the last two decades has markedly raised the incidence. Fast-moving, mechanized warfare has further sharply augmented the number of such cases.

Here is an example typical of many. During the secret flanking move of the 4th Indian Division in Tunisia from the 8th Army, held at Enfidaville, to share in the final break through to Tunis from the West, a tank transporter's brakes failed on a mountain pass. The driver, *faute de mieux*, "took a house" to check his career. When he was dug out from beneath the transporter and house debris, he was found to have a posterior dislocation of the hip. Under difficult circumstances, two attempts were made to reduce this but without success. Finally, 36 hours later, after a truck journey of 150 miles, much of it over mountain tracks, he arrived in the small hours at a 1st Army General Hospital, where, with some effort, reduction was effected.

The writer has seen more dislocated hips during the war years than in twice as many pre-war years, even though these were spent in a region where road accidents were perhaps above the average for the country.

It is, then, an accepted fact that this 'dashboard dislocation' is now the commonest type of traumatic dislocation (Funster et al, 1938). The right is the more frequently injured hip, and posterior dislocation is reported to be seven times as common as anterior (Walker, 1940). The victim, usually the front-seat passenger (Watson-Jones, 1944), is sitting with the hip flexed and adducted. A head-on collision occurs, the knee hits the dashboard, and the head of the femur, which in this position lies almost entirely out of the acetabular cup, is forced through the capsule posteriorly. Often this is complicated by a fracture of a greater or lesser portion of the posterior acetabular rim.

The main interest in this report is the triplication of the lesion—three cases from one accident. Cases of bilateral fracture-dislocation have been reported (Gardiner, 1939, Taylor, 1940), but a search, rather superficial owing to the "exigencies of the Service", of the recent literature has failed to disclose so multiple a series of lesions.

### CASE REPORTS

On June 29, 1945, a left-hand drive Command car was proceeding along a typical tree-lined *pavé* road near the Franco-Belgian frontier after a shower of rain. Such road surfaces are notoriously skiddy and this was no exception. On a slight bend the car, which was



3 Patient moved to mattress on floor and with assistant steadying lightly bandaged right leg, the dislocation of right hip reduced without difficulty by 'lifting' head into acetabulum

4 Application of plaster (padded and split) on right leg fractures with a slight manual traction—from base of toes to mid-thigh

"Left ankle Almost perfect reduction—slight residual lateral subluxation"

Further progress was uneventful except for urinary retention, which once required catheterization. The right lower limb was partially immobilized by sandbags, but in view of the multiplicity of injuries, no attempt was made either to extend limb or to nurse patient on



FIG 435—Cpl U A, Before manipulation. Comminuted fracture dislocation of right hip. Femoral head displaced upwards and backwards. Thin fragment of rim of acetabulum (approx 1 in long) detached posteriorly and displaced with head. Also oblique fracture through acetabulum. B, Full pelvis after manipulation. Showing wide separation of symphysis pubis and splaying of right sacroiliac joint. C, After manipulation. Reduction of dislocation complete. Rim fragment still displaced.

5 Toilet and suture of lacerations of eyebrows and elbow

6 Passing of catheter—clear urine withdrawn

Plasma infusion (2 bottles) given during operation, which took 90 minutes. Condition at end satisfactory

Post-operative radiographs were taken later—

"Right hip. Reduction of femoral head complete. The rim fragment remains widely displaced" (Fig 435, C)

"Right leg. General alignment of fragments surprisingly good under circumstances. Some angulation"

his side or in sling to allow pelvis to close. For administrative reasons, he and Sgt D were transferred on July 8 (the ninth day) to a U.S. General Hospital.

SUBSEQUENT HISTORY—On inquiry on July 24 we learnt that "progress was excellent." Os calcis pin traction to right lower limb and pelvic slinging (with partial reduction of spread of pelvis) had recently been instituted.

Sgt D (aged 25)—This man was last examined. He was in good general physical condition, but more



"hit up" There was the typical deformity of a posterior dislocation of the left hip and internal rotation and adduction of hip with flexion of knee and hip, in addition he showed marked swelling of the right ankle. This, however, proved to be a very severe sprain with no bony lesion. He was X-rayed "Left hip. Comminuted fracture-dislocation. Head dislocated upwards and backwards. A segment (at least one-quarter of rim) of acetabulum detached posteriorly and displaced

days, probably due to absorption from hematoma of left thigh and right ankle, but this did not appear in any way to affect his general condition, which remained good throughout. He was transferred on July 8.

**SUBSEQUENT HISTORY**—By July 24 it was reported that the displaced acetabular fragment had been removed operatively. Traction had been maintained and it was proposed shortly to apply a plaster spica. "Convalescence uneventful."

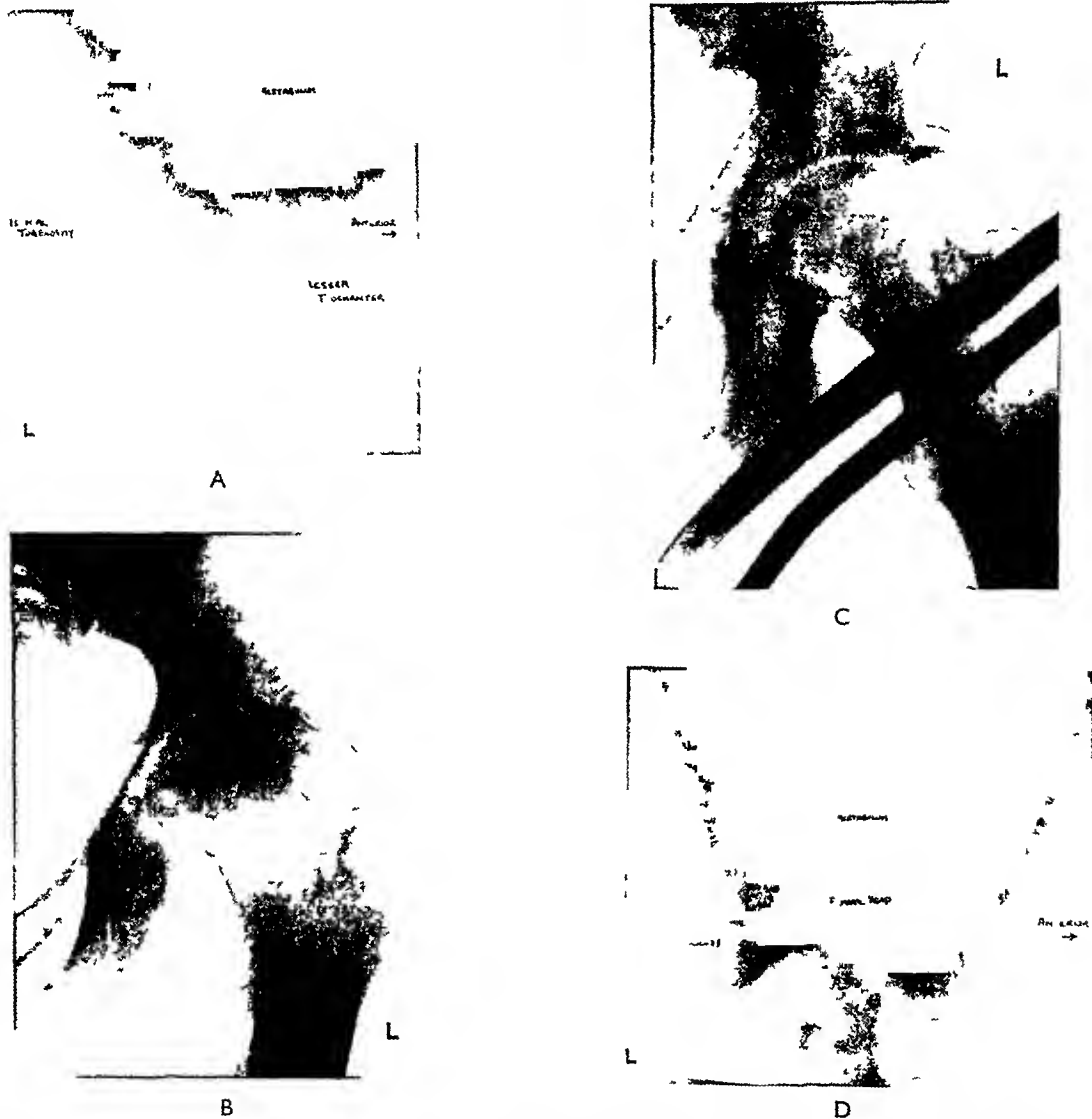


FIG 436—Sgt. D. A, B, Before manipulation. Comminuted fracture-dislocation of left hip, femoral head displaced upwards and backwards. A segment, which includes at least one-quarter of rim of acetabulum, has been fractured and displaced with head. Also fracture through acetabulum and tuber ischi. C, D, After manipulation. Reduction of dislocation complete. Rim fragment still widely displaced and at right angles to its normal position.

upwards with femoral head. Also linear fracture from acetabulum to tip of tuber ischi" (Figs 436, A, B).

At 23 30 hr, under pentothal (g 1) anaesthesia, this left dislocation was reduced as in the previous case, and fixed Thomas splint strapping extension applied, the right ankle was immobilized in a padded plaster.

Post-operative radiographs confirmed the reduction of the dislocation, but the acetabular fragment, although nearer, remained widely displaced and at right angles to its true position (Figs 436, C, D). In this case again there was temporary dysuria and catheterization was necessary once. There was some pyrexia for a few

## DISCUSSION

The concomitant occurrence of a fracture of the acetabular ring increases the severity of the lesion and makes the ultimate prognosis of dislocated hip less hopeful.

More often than not the displaced fragment follows the head on reduction and is replaced into normal or almost normal position. In these cases this did not transpire. In the case of Cpl U, in view of the small size of the fragment and the presence of the other injuries, no further attempt

was made to replace the rim fragment, but Sgt D's larger fragment was removed.

To lessen the risk of redislocation, it is more usual to attempt replacement rather than removal, but the operation was carried out elsewhere and one cannot tell what was actually found at operation.

The damage to the acetabular ring by fracture renders the hip potentially unstable, and it is important to maintain traction for four to six weeks and immobilization for a yet longer period. These measures also lessen the risk of traumatic myositis ossificans, avascular necrosis of the femoral head, and osteo-arthritis—all these not infrequently follow this type of injury.

There was no evidence of any sciatic nerve palsy in either case.

The force applied to the pelvis was so severe that it not only produced a fracture-dislocation of the hip and split the pelvis from acetabulum to tuber ischii in the second and third cases, but in the second also disrupted the pelvic ring, it is not, then, surprising that micturition was temporarily disturbed. Separation of the symphysis pubis is frequently associated with extraperitoneal rupture of the bladder.

The pelvic lesion of the driver (Cpl A) was the least serious of the three. The grip on the steering wheel is thought to have checked the momentum

of the driver and so lessened the force of his impact, but unfortunately his head also hit something, probably the tree, with fatal results.

### SUMMARY

1 A description is given of three cases of fracture-dislocation of the hip (all had other injuries in addition) occurring simultaneously in one car accident.

2 The condition is briefly discussed.

I wish to express my thanks to Col L Handy, A M S (Commanding Officer of the General Hospital), to Major D W Seth Smith, R A M C, and Sergt H A Burgess, R A M C, of the Radiological Department for their skilled assistance, and to Capt A G T Brown, R A M C, for his excellent sketches.

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## SIMULTANEOUS CARCINOMA AND TUBERCULOSIS OF THE COLON REPORT OF A CASE AND REVIEW OF THE LITERATURE

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THE association of active tuberculosis with carcinoma has been recorded in most of the organs of the body. The commonest sites are the skin, larynx, and lung, where the development of cancer is commonly a complication of chronic tuberculous ulceration. The stomach, colon, uterus, and testicle, which are less often infected by tuberculosis, have nevertheless, provided numerous instances of this double pathology. In reviewing the colonic cases the writers were struck by the preponderance of ileocaecal cases. As the ileocaecal region is by far the commonest site for colonic tuberculosis, the frequent association of the two conditions here seems to indicate that the tuberculosis precedes the carcinoma. It could be argued, on the other hand, that the massive type of carcinoma commonly found in the caecum is more likely to provide a suitable nidus for the growth of ingested tubercle bacilli than the relatively smaller and less necrotic cancers which occur in the right colon. Our case is of interest in being the only recorded instance of this association in the region of the splenic flexure, which is a very rare site for colonic tuberculosis.

The coexistence of the two diseases seems to have been first reported by Bayle in 1810. Rokitsky in 1854 taught that the two diseases were

antagonistic, a view which has had its proponents and antagonists up to the present time. Thus Lubarsch in 1888 found among 2668 cases of tuberculosis 117 (4.4 per cent) with associated carcinoma, and among 569 cases of carcinoma 117 (20.6 per cent) with tuberculosis. Of 5967 cases without carcinoma 2251 (42.7 per cent) were tuberculous. These figures indicate that carcinoma is twice as frequent in non-tuberculous patients and that tuberculosis is twice as frequent in non-carcinomatous patients. More recently, Pearl (1929) studied the association of the two diseases in 7500 autopsies and concluded that the antagonism was sufficient to support the treatment of cancerous patients by tuberculin.

The opposite view was well expressed by Carlson and Bell (1929), who, after studying 1,195 cases, reported Pearl's conclusions unjustified and remarked that the only way in which active tuberculosis can be said to prevent cancer is by killing the patient before it develops. Cooper (1929) analysed 247 cases in which the two diseases occurred in the same organ and concluded that their simultaneous occurrence was sufficiently frequent to disprove a mutual antagonism. Among his collected cases are 48 in the gastro-intestinal tract, of which 23 were in the

# CARCINOMA AND TUBERCULOSIS OF COLON

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large intestine One other case has been recorded in the literature since his paper in addition to the one reported below

## CASE REPORT

Mrs H E, a married woman, aged 67, was admitted to hospital on April 12, 1945, for recurrent attacks of abdominal pain, diarrhoea, and vomiting

HISTORY—As the patient was confused and garrulous this was unreliable She had noticed an abdominal tumour for some months, had felt weak and ill for the same time, and about three weeks before admission

opened it became apparent that the muscle and underlying peritoneum were being infiltrated by the growth A part of the muscle and peritoneum was therefore left attached to the tumour and eventually removed with it The growth was found to be arising from the left end of the transverse colon, where it was attached to the greater curvature of the stomach It extended downwards in front of the descending colon, to which it was also attached There were no secondary deposits in the liver, the mesocolic glands could not be examined at this stage, owing to the large mass in front of them The descending colon and splenic flexure were mobilized, the iliac and transverse colons divided, and the greater



Fig 437—Drawing of tumour

began to suffer from recurrent attacks of colic and vomiting, followed by diarrhoea These attacks lasted for a day or two and were accompanied by abdominal distension Her appetite was poor and the stools were normal in appearance without overt blood or mucus

ON EXAMINATION—She was slightly confused mentally, and appeared moderately anaemic Her pulse was 88, temperature 98°, and blood-pressure 130/75 There were no abnormal signs in the chest, and this was normal on X-ray examination The abdomen was distended and there was a hard irregular mass occupying most of the left hypochondrium, flank, and iliac fossa It could not be moved independently of the anterior abdominal wall, but was not fixed posteriorly The liver was not enlarged Rectal examination was normal and there were no signs of free fluid in the abdomen

Investigations—A barium enema showed some narrowing of the pelvic and splenic flexure regions of the colon, but the barium flowed quite freely past the narrowings The appearances were rather suggestive of external pressure

The blood-sedimentation rate was 25 mm in an hour (Cutler's method)

Red blood-count 4,550,000 per c mm

Haemoglobin 64 per cent Haldane

Total white count 8000 per c mm

Colour index 0.71

Differential count within normal limits

A provisional diagnosis of either a colonic or ovarian carcinoma was made and the patient operated on after a week's preparation

AT OPERATION—The abdomen was opened through a left paramedian incision As the rectus sheath was

curvature of the stomach resected The growth was now free and was liberated by dividing the left part of the transverse mesocolon At this stage glands were discovered in the root of the mesocolon which could not be removed entirely owing to their relation to the superior mesenteric artery One of these was removed separately and was later proved to be tuberculous

The transverse and iliac colons were joined by end-to-end anastomosis and the stomach repaired The abdomen was closed with some difficulty owing to the defect left by the removal of a considerable part of the rectus muscle and peritoneum

The patient stood this operation very well and was returned to her bed in good condition

POST-OPERATIVE PROGRESS—This was uneventful until the eleventh day, when the wound burst open in the centre and discharged a little pus The dehiscence, which involved skin only, slowly spread up and down, until about one month after the operation a typical tuberculous ulcer, about three and a half inches long and half an inch across involved the greater part of the scar This was excised by diathermy and the floor curetted vigorously The response to this treatment was most satisfactory The wound is now healed formed within a week, and the wound is now (three months post-operative) almost completely healed

DESCRIPTION OF THE TUMOUR—The tumour (Fig 437) measured about 6 in in its largest diameter and had portions of the rectus muscle and stomach attached to its surface On section the centre of the mass presented the typical appearance of a massive carcinoma of the colon and was of a greyish colour, flecked with

hæmorrhages The peripheral part was yellow and had the appearance of a caseating tuberculous granuloma All the glands sectioned were typically tuberculous to the naked eye



FIG 438—Section of gland—tuberculosis only

centre of the mass (Fig 439) showed a well-differentiated adenocarcinoma undergoing necrosis Intimately mixed with the cancer cells was an active tuberculous process, the two lesions being visible in the same microscopical



FIG 439—Section of tumour—carcinoma and tuberculosis

Microscopically, the glands showed typical cascating tuberculosis with many Langhans cells (Fig 438) There was no sign of carcinoma in any of the numerous sections which were examined Sections from the

field in several places The carcinoma did not penetrate deeply and sections taken of the periphery of the mass and the invaded abdominal wall showed tuberculosis only

DATE	AUTHORITY	AGE AND SEX	SUMMARY
<b>1 Ileocaecal Tuberculosis and Cancer —</b>			
1897	Naegeli	—	T B and colloid cancer of caecum T B in mesenteric nodes, not in growth
1897	Metterhausen	35, F	Adenocarcinoma of ileocaecal region T B granulations invading growth
1900	Crowder	54, F	Carcinoma of caecum with tuberculous nodes
1903	Letulle	—	6 cases of carcinoma of appendix in tuberculous patients In one they were associated in the appendix
1908	Buday	—	T B fistulous tract leading to carcinoma of appendix
1910	Stetten	—	T B and carcinoma of caecum
1917	Forman and Cameron	—	Adenocarcinoma of caecum with tubercles beneath the peritoneum
1921	Herrenschmidt	—	Carcinoma of caecum T B nodes
1921	Hartmann and Renaud	—	T B and carcinoma seen in the same microscopical field of caecal tumour
1926	Hamperl	51, M	Adenocarcinoma and T B of caecum
1926	Hamperl	47, F	Adenocarcinoma and T B of caecum
1927	Hamperl	17, F	Adenocarcinoma and T B of caecum
1927	Harbitz	30, F	Two cases of associated cancer and T B of ileocaecal region Both diseases intimately mixed
1930	Cooper	28, M	Adenocarcinoma of ascending colon T B of appendix stump
1930	Cooper	44, F	Adenocarcinoma of ascending colon T B of mesenteric nodes
1930	Harada	48, M	Carcinoma and T B of caecum
1936	Hoeffel	54, F	Carcinoma and T B of caecum causing acute obstruction
1935	Safwenberg	42, F	Carcinoma and tuberculosis of ascending colon and ileocaecal valve
1935	Safwenberg	57, M	Carcinoma and tuberculosis of ascending colon and ileocaecal valve
<b>2 Sigmoid Cancer and Tuberculosis —</b>			
1902	Moak	—	Adenocarcinoma and T B in sigmoid Metastases of both in the liver and kidney
1903	Guberman	—	Adenocarcinoma of sigmoid with T B cascation around the growth
1910	Tauschwitz	36 M	Both conditions in sigmoid
1917	Reinhardt	69, F	Stenosing cancer of sigmoid with tubercles in serosa Older tubercles in lung
1936	Müller	62, M	Patient died of phthisis At P M mass in descending colon Mixed tubercle and cancer
<b>3 Rectal Cancer and Tuberculosis —</b>			
1902	Phen	34, F	Malignant ulcer of rectum with tubercles within it
1910	Stettin	—	Carcinoma and tuberculous fistula-in ano
1925	White	—	Carcinoma of upper rectum with metastases in liver, also T B in rectum and regional glands
1937	Uher and Rapant	33, F	Carcinoma of rectum with typical tubercles between islets of carcinoma

Tubercle bacilli were seen in Ziehl-Neelsen films of the tumour and the glands

### SUMMARY OF PREVIOUSLY REPORTED CASES

Owing to the inadequacy of some of these reports it is impossible to criticize these cases in detail. It is apparent, however, that in many the condition was cancer of the bowel with tuberculosis of the regional glands, which might well have been of long standing and unrelated to the carcinoma. The cases reported as carcinoma of the appendix might now be regarded as carcinoid tumours

### COMMENTARY

Lubarsch (1888) states that the association of tuberculosis with cancer may occur in any of the following ways —

1 A chance coincidence without any apparent relation

2 Metastatic carcinoma developing in an old tuberculous lesion

3 Secondary infection of carcinoma with tuberculosis

4 Chronic progressive tubercle in which a carcinoma develops

5 Simultaneous development of both

In such a case as ours it is impossible to be certain how the condition arose. The absence of fibrosis in the tuberculous lesion and of old tuberculous glands with calcification makes it improbable that the tuberculous lesion was of long standing, and the absence of a pulmonary lesion with tubercle bacilli in the sputum is against the assumption that a primary carcinoma was secondarily invaded by swallowed tubercle bacilli. Certainly the tuberculous process seems more active than the carcinoma, but that does not prove that it preceded the latter

### SUMMARY

A case of associated active tuberculosis and cancer of the splenic flexure of the colon is described

The literature is reviewed and the question of the aetiological relationship of the two diseases is discussed briefly

We have to thank Dr A Elliott, County M O H, for permission to report this case, which was treated by us at the County Hospital, Farnborough, Kent. Also, Mrs Helen Randall for the coloured illustration of the specimen, and Mr J E Andrews, of the Southern Group Laboratory, L C C, for the microphotographs

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## SOLID TUMOURS OF THE EPIDIDYMISS

### REPORT OF TWO CASES

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TUMOURS of the epididymis are still admittedly regarded as rare, yet one of the present writers has in five years seen three such tumours of glandular type, which are similar to one another and which closely resemble those described by Taylor and Davis (1941), and Mackay (1943), and which, moreover, seem related to the tumours described by Halpert (1941), and Friedman and Grayzel (1942). Mackay (1943) observed the essential similarity

of the "adenocarcinomata" of Thompson (1936), the "adenomata" of Taylor and Davis (1941), and of Blumer and Edwards (1941), and the "lymphangioma" of the literature, he himself added two cases. He regarded the tumours as "mesotheliomata".

Of the three tumours mentioned in the first paragraph, one was described and figured in this JOURNAL by Blumer and Edwards (1941), brief accounts of the other two follow

## CASE REPORTS

## Case 1—

CLINICAL DETAILS—A W., aged 34 Examined Dec 11, 1943 Stated he had had painless testicular swelling for some years which had been getting larger

the scrotum He had had no pain, but had a certain amount of discomfort On examination a small firm swelling, the size of a small marble and apparently attached to the globus minor of the left epididymis, was found The tumour was well defined and obviously not malignant, and it was concluded, in spite of its



FIG 440—Case 1 Typical tubules ( $\times 60$ )

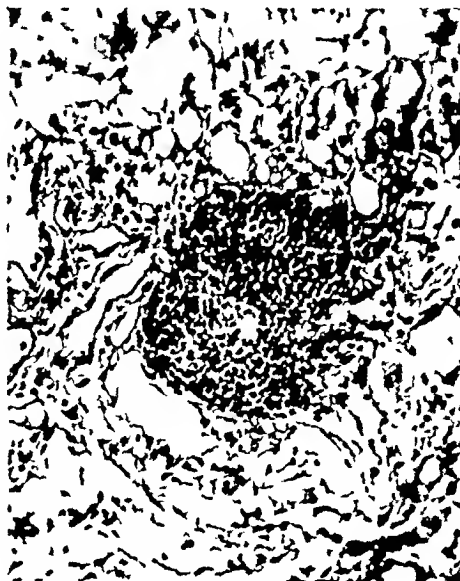


FIG 441—Case 1 Lymphatic collections ( $\times 150$ )



FIG 442—Case 2 Typical tubules ( $\times 60$ )



FIG 443—Case 2 Lymphatic collections ( $\times 200$ )

recently A small tumour of lower pole of right testicle

OPERATION (Jan 25, 1944)—Exposure of right testicle A solid tumour of lower pole of epididymis was resected

## Case 2—

CLINICAL DETAILS—A J T., aged 43, a carpenter On Nov 10, 1943, he stated that for some months he had had a small swelling on the left side of

position, that it was probably a spermatocele Its removal was advised, but as he was unwilling to submit to this, a suspensory bandage was fitted In February, 1945, the tumour was slightly larger Its removal was again advised, and this time he agreed

OPERATION (April 11)—A left inguinal incision was made and the left testicle exposed A small hydrocele was present and the tumour in the globus minor This was removed without difficulty



## THE SPECIMENS

These were similar. The first measured approximately 2 cm × 2.2 cm, the second 1.7 cm × 1.25 cm. Both were firm to the touch and the cut surfaces yellowish-white in colour.

**MICROSCOPICAL EXAMINATION**—Each tumour shows a fibrous capsule containing plain muscle-fibres in varying amount. Within the capsule the tissue consists of what irregular, some flattened, some cubical. The tubules lined by a single layer of cells which are sometimes rounded and vesicular. The tubules, though usually empty, in places contain wisps of homogenous pink-staining fluid, and occasional cells, which are probably shed from the walls, are seen. No mitotic figures were seen. Collections of lymphocytes, having the appearance in one or two instances of 'germinal centres', are scattered amongst the tubules (*Figs 440-3*).

The foregoing description would fit both tumours, however, a difference is noticeable in regard to the distribution of plain muscle, in the first, plain muscle is present in the capsule and in the walls of blood-vessels—larger than capillaries—but in addition, substantial bundles of interlacing plain muscle and collagen extend centripetally at one point from the capsule, in the second, plain muscle is seen only in the capsule and vessels.

## DISCUSSION

The resemblance between these two tumours and the tumours described as "adenomata" by Taylor and Davis (1941) and Blumer and Edwards (1941) is close. The possible diagnoses are discussed in the latter paper, the most likely would seem to be 'adenoma', 'angioma', or 'endothelioma' (which term is held to include 'mesothelioma') Mackay (1943), as already mentioned, noted the similarities of the tumours to those described as "adenocarcinomata" by Thompson (1936) and "lymphangiomata" by various authors. He regarded them as "mesotheliomata", but the presence of plain muscle inside the capsule in our first case seems to provide a transition between 'glandular' tumours and the "mixed leiomyoma and lymphangioma" of Halpert (1941) and the "adenomyoma" of Sakaguchi (1915). Moreover, since the tumour described as "myoma" by Friedman and Grayzel (1942) contained "glandular structures", it seems probable that other 'leiomyomata' contained 'glandular' elements, and were of the same essential nature. Plain muscle is, of course, found in close proximity to epithelial elements in the epididymis. Several of the 'glandular' tumours, including our two specimens, contain lymphocytic collections showing apparent 'germinal centres', Thompson (1936) in his review mentioned a "lympho-endothelioma", and Sakaguchi's case (1915) showed lymphoid tissue. The more irregular of the cells lining the tubules resemble somewhat the cells in the sinus of a developing lymph-gland, and in the literature tumours—apparently identical in form, as

Mackay (1943) observed—are described as "lympho-angiomata", yet the tubules are almost invariably empty. This seems a difficulty to the present writers. Again, whereas the presence of 'germinal centres' does perhaps speak for such a diagnosis, it is by no means conclusive evidence, as witness, for example, the dense lymphoid masses in adenosquamous epithelium to lymphoid tissue in lympho-epithelioma. The nature of these last two tumours is still debated, but no one supposes, it is conceived, that either is a lymphangioma. It must be conceded that the distinction of epithelium from endothelium can be a most embarrassing inquiry. It is here submitted that the morphology of the cells lining the tubules provides inconclusive evidence as between 'endothelioma' (or 'mesothelioma') on the one hand, and 'adenoma' on the other. The wide variations between the cells in individual examples of the 'mixed tumours' of salivary glands will be recalled, yet many authors regard these tumours as adenomata of the salivary glands and the cells as epithelial, e.g. Harvey and others (1938). Lymphoid tissue is occasionally seen in these tumours also.

Since 'glandular elements', plain muscle, and lymphoid tissue with 'germinal centres' are associated in many of the tumours, and since their origins are still debated, perhaps the least objectionable, and most non-committal, designation would be 'mixed tumours' of the epididymis, as in the case of the salivary glands the term is held not to possess the implications of teratoma. The tumours appear to be benign, and the history often covers many years, but the post-operative period is in most cases not yet long enough to be significant.

## SUMMARY

Two, apparently benign 'adenomatous' tumours of the epididymis are described. The relationship of such tumours to 'lymphangioma' and 'myoma' in the same site is discussed.

We wish to thank Mr T C Dodds for the photographs and Mr W Blackie for technical assistance.

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## CONGENITAL ATRESIA OF THE COMMON BILE-DUCT

### REPORT OF A SUCCESSFUL CASE

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THE subject of congenital anomalies of the bile-passages has been fully described in recent years by Ladd and Gross (1941), Donovan (1937), Strauss and Gross (1943), Chesterman (1941), and others, and in reporting this case there is little to add to their description.

Other writers have stressed the importance of searching for other congenital anomalies which are liable to occur in the same subject. The severe pyelitis which complicated our case is probably associated with a congenital anomaly of the urinary tract, and a genito-urinary investigation will be undertaken when the child is a little older.

Laparotomy in this case was performed at the early age of 5 weeks, considerably earlier than in most of the reported cases. This was owing to the recent advances in serology which have made diagnosis from icterus gravis simpler and more certain. As soon as the diagnosis is made and the child is in reasonable condition, the operation should not be delayed. Even at the age of 5 weeks severe changes had taken place in the liver and it is probable that such changes are progressive and tend to become irreversible.

### CASE REPORT

R McQ, male, born on Sept 20, 1944.

**HISTORY**—His birth weight was 7 lb 12 oz and the delivery was normal. He was quite well until 15 days old, when jaundice developed and rapidly increased. Stools were slimy and light yellow in colour and the urine became darker. He had been breast fed for the first three weeks and then changed over to half-cream dried milk. The highest weight reached was 8 lb 1½ oz.

**Family History**—The parents and elder sister were alive and well. There was no history of jaundice or of any congenital defect.

**ON ADMISSION (Oct 17)**—He was approximately a month old and his weight was 7 lb 12 oz. Nutrition then seemed fair, but he was deeply jaundiced. The abdomen was distended. The spleen and right kidney were just palpable and there was an umbilical hernia. The urine contained many pus cells, a cloud of albumin, and coliform bacilli, a large quantity of bile-pigments, but no bile-salts.

#### *Blood-count* —

2.9 million red cells  
60 per cent hæmoglobin  
1.0 colour index  
26,000 leucocytes with 77 per cent neutrophils  
No nucleated red cells were seen in the film  
Red blood-cells were of normal fragility  
Kahn reaction was negative

Van den Bergh positive direct reaction, indirect  
16 mg bilirubin per cent

**Blood grouping** showed that both mother and baby belonged to Group O (IV) and were rhesus-positive. Bile-pigments were absent from the fæces.

A diagnosis of congenital atresia of the bile-duct was made and laparotomy decided upon.

For 7 days prior to operation sulphathiazole, 0.125 g four-hourly for 24 hours, then 0.125 g six-hourly was given. A specimen of urine just before operation on Oct 24 showed a few leucocytes, no casts or red blood-cells, and much bile-pigment. The red cells and hæmoglobin were as before, but the leucocytes had increased to 60,000, with 87 per cent polymorphs. During this time and until Oct 26 he ran a low-grade pyrexia, and on Oct 24, the day before operation, 5 mg of 1:4 dicetoxy-2-methylnaphthalene in oil were given, and also 150 c.c. of normal saline, subcutaneously.



FIG 444—Photograph of patient at 11 months

#### **OPERATION** —

**Anæsthesia** (Dr John Ives) The abdominal wall was infiltrated with ½ per cent procaine, and light ether administered.

**Incision** Upper right paramedian, splitting the rectus muscle.

**Findings** The liver was enlarged and firmer than normal. The gall-bladder was not appreciably enlarged, but on dissecting out the common bile-duct this was found to be somewhat dilated (about 3 mm in diameter) and ceased abruptly just before the upper border of the duodenum was reached. On compression, the gall-bladder emptied and some distension of the blind end of the common duct was produced, indicating patency of the cystic duct. On aspiration the gall-bladder was found to contain very pale bile.

**Procedure** Cholecystogastrostomy appeared to be the easiest method of establishing a communication with the alimentary tract. The fundus of the gall-bladder

was therefore freed from the liver and sutured to the stomach for a distance of about 1 cm, using interrupted 000 chromic catgut sutures, placed very close together. Incisions were then made into the gall-bladder and stomach, and the anastomosis completed by a similar row of sutures anteriorly. A second line of sutures was not attempted, owing to the extremely small size of the structures.

**POST-OPERATIVE COURSE**—On the day after operation, constipated stools were passed consisting of pure white faecal matter. Eight days after the operation it was noted that the jaundice was still marked but the urine contained less bile-pigment. The child was running a high temperature and was extremely dehydrated and wasted. The urinary deposit still showed many pus cells.

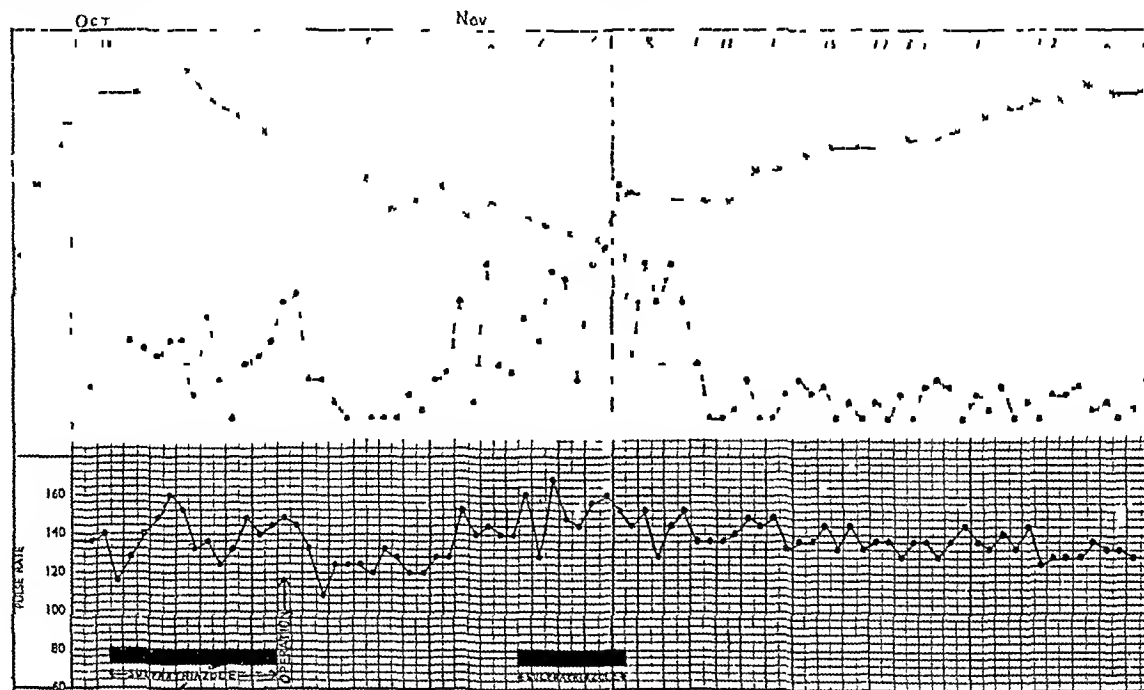


FIG 445—Temperature, pulse-rate, and weight chart, Oct 17–Nov 27

The abdomen was closed in layers without drainage.  
Operating time 40 minutes

#### POST-OPERATIVE TREATMENT—

Days after Operation	Treatment
0	250 c.c. of saline intravenously, with 5 per cent glucose, followed by 150 c.c. of Group O stored blood. 1-oz feeds of 5 per cent dextrimaltose 2-hourly, commencing 4 hours after operation.
1	2-oz feeds of 5 per cent dextrimaltose 2-hourly.
2	2-oz feeds of 5 per cent dextrimaltose with $\frac{1}{2}$ drachm half-cream dried milk added.
5	4-oz feeds containing 2 drachms dextrimaltose and 2 drachms half-cream dried milk 3-hourly.
7	Sulphathiazole commenced (0.25 g followed by 0.125 g 4-hourly), 20 c.c. whole blood given intramuscularly.
8	20 c.c. whole blood given intramuscularly. Subcutaneous saline commenced.
9	Subcutaneous saline stopped.
11	Sulphathiazole stopped.
12	275 c.c. plasma, together with an equal amount of half-normal saline given subcutaneously.
13	
15	
21	5-oz feeds containing 2 drachms dextrimaltose and 3 drachms half-cream dried milk 4-hourly.

Eleven days after the operation the stool was first noted to have bile-pigments. The blood-count had improved, there being 3.4 million red cells, and 68 per cent haemoglobin.

The urinary deposit still showed many pus cells.

Fourteen days after the operation the baby was found to be very much less jaundiced. The stool had much more bile-pigment and the general condition was improved. From that time until his discharge the jaundice grew less, more pigment appeared in the stools, and the urine became clear.

The pyrexia subsided on the sixteenth post-operative day and from then until the thirty-second day there was a steady gain in weight from 6 lb 12 oz, the lowest weight reached, to 7 lb 12 oz.

For the next four days there was a fall in weight to 7 lb 4 oz associated with mild diarrhoea, which responded to a slight reduction in the strength of the formula.

On his discharge, fifty days after the operation, when he was twelve weeks old, his weight was 8 lb 12 oz.

#### DISCUSSION

**Differential Diagnosis**—In this case differential diagnosis was not difficult. It was important to exclude icterus gravis neonatorum. The late onset of the jaundice, together with the fact that the mother and child were both rhesus-positive, and the absence of an erythroblastic picture in the blood-film, ruled out this, the most important, alternative. The presence of obstructive jaundice would not be conclusively against this diagnosis, as in certain of the more severe cases of this disease, so great is the

blood destruction that an obstructive jaundice is caused by the blocking of the bile-ducts. Anæmia may occur as a secondary manifestation in any infection, so is not a helpful diagnostic feature. Congenital syphilis would only exceptionally give rise to a severe jaundice, a mild degree of jaundice, coupled with hæmorrhages, a rash, enlarged liver and spleen, and radiological changes in the long bones, would be expected. Acholuric jaundice rarely gives rise to severe jaundice of obstructive type at such an early age, and a mild jaundice with anæmia and increased fragility and micro-spherocytosis, are more commonly found.

Physiological icterus does not really enter into the question as it clears up early and is not severe. Jaundice due to sepsis is uncommon and the severe constitutional disturbance and the presence of bile in the stools would exclude it.

Infective hepatitis has not, so far as we are aware, been reported in so young an infant. The long incubation period would at least make it unlikely to occur before the child was four to six weeks old, unless the mother was also infected, when

she would also become jaundiced. The van den Bergh would be biphasic.

Obstruction by a mucus plug can only be diagnosed at operation, as it presents the same clinical picture.

We have recently seen a case of severe jaundice and anæmia associated with intraperitoneal hæmorrhage due to a ruptured hæmangioma of the liver in a neonate.

### SUMMARY

A case of congenital atresia of the common bile-duct is described. Cholecystogastrostomy was performed with a successful outcome.

This is the ninth successful case reported in the literature, and apparently the first in this country.

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## OSTEOCHONDRITIS DISSECANS AND TORN LATERAL MENISCUS

MAJOR J. G. BONNIN, R.A.M.C.

THE absence of universal agreement as to the aetiology of osteochondritis dissecans makes its association with a torn lateral meniscus worth recording. It is to be noted that the lateral condyle, which is the less commonly involved, was affected. There appears to be no doubt in this case that trauma was the aetiological factor, and that the displaced cartilage which followed the injury may have secondarily caused the development of osteochondritis.

### CASE REPORT

**HISTORY**—E. E., aged 36, a private in the Army, was admitted on account of pain in the right knee, following a long history of attacks of locking. He stated that

seven months previously he jumped from a platform and "fell hard." He felt a "jarring" in the knee, and on picking himself up found he was unable to straighten the knee. He was able to walk on the toes. On the following day the knee was slightly flexed but there was little swelling. He hobbled around for six weeks, by which time the knee was almost straight. On one occasion when going up stairs the knee locked and it has locked twice subsequently, the patient being able to release it himself. He complained of increasing pain in the joint, particularly after standing.

**ON EXAMINATION**—There was slight wasting of the quadriceps and a small effusion. There was a full range of movement, some tenderness was present over the anterior end of the external cartilage. There was no laxity of any ligament. A clinical diagnosis of torn

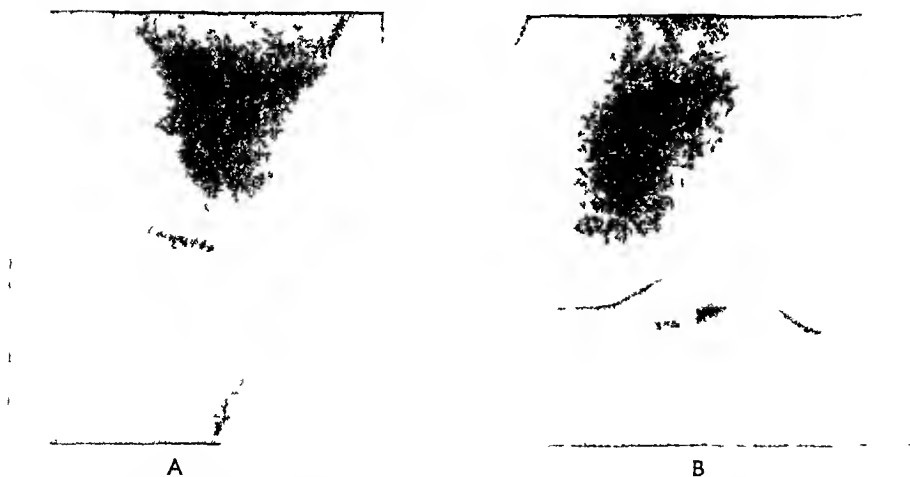


FIG. 446.—Radiographic appearances before operation. A, Lateral view. B, Antero-posterior view.

lateral meniscus was agreed upon, and a routine radiological examination made. The appearances were as shown in Fig 446, A, B. There was a well-marked osteochondritic focus in the lateral condyle of the femur, with a small dense area surrounded by a zone of decalcification. The osteochondritic fragment had thus not yet separated into the joint. Some suspicion was felt with regard to the diagnosis, but, in consultation with Major-General Max Page, it was decided to explore the joint and to drill the damaged fragment in the hope of revascularizing it and attaching it to its bed.

**OPERATION**—Accordingly the joint was opened in the usual manner and the lateral condyle exposed. A curved fissure in the articular cartilage of the femoral condyle was noted, the curve being convex forwards, and the posterior lip being depressed to the depth of the cartilage, in the same manner as a depressed fracture of the cranial vault. On inspecting the cartilage, a complete bucket-handle tear of the cartilage was seen lying turned over on itself in the midline of the joint (Fig 447). The

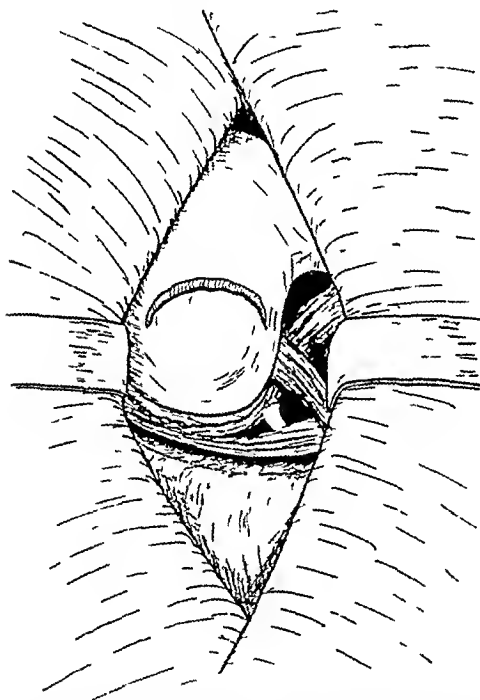


FIG 447—The appearance at operation, showing the right lateral meniscus detached from the periphery and turned into the middle of the joint

complete congruity of the curve of the displaced cartilage and the cartilaginous fracture on the condyle was at once apparent, and on extending the knee the cartilage was found to fit over the depressed fragment and to depress it still further. The cartilage was detached from its anterior attachment and removed completely (Fig 448). Fifteen holes with a  $\frac{1}{16}$ -in drill were made through the depressed cartilaginous area into the condyle of the femur, and the joint was closed.

**PROGRESS**—Little reaction followed—early movements were prohibited and at the end of a fortnight a knee-fixation plaster was applied and the patient allowed limited activity in it. Six weeks later the plaster was removed. The radiological appearances then were an apparent increased density of the bony fragment due to general decalcification and it was slightly rotated, suggesting that it was lying loose under the cartilage, but the articular cartilage over it appeared whole, while the fragment was slightly reduced in size. There was no effusion.

With the commencement of active movements the effusion recurred. A full range of movements returned in three weeks.

Ten weeks from the removal of the plaster there was still a small effusion, the patient could walk four miles comfortably, and had no complaints.

He was transferred to a Convalescent Depot and returned to duty in category B 7.



FIG 448—Photograph of the lateral meniscus, removed at operation, lying in the position it occupied in the joint

## DISCUSSION

No claim can be made as to the effectiveness of the operation. The clinical condition of the knee before and after operation was much the same. The radiological appearances show the fragment to be reduced in size and of similar density, and to be maintaining its attachment to the condyle. The association of osteochondritis dissecans with lesions of the menisci was found in three cases by Fairbank. In two the internal meniscus was damaged, and in one the external meniscus, but in this case the medial condyle was involved. No records could be found of the association of a torn external meniscus and osteochondritis dissecans of the external femoral condyle.

The continued movement of the damaged cartilage on the femoral condyle, as it came in contact with the displaced meniscus, may explain the failure of the bony fragment to redevelop a blood-supply, an hypothesis which has been supported by Timbrell, Fisher and Fairbank. It is noteworthy that the lesion is only seen on curved surfaces which are the subject of frictional strain—the capitellum, the upper surface of the talus, and the superior aspect of the femoral head. The occurrence of a subchondral separation under excessive frictional strain could thus be accounted for without the necessity of searching for a prominence against which the condyle impinges. In this case the impingement appears certainly to have been on a displaced meniscus. Whether that alone would give rise to the condition, or whether the continued minor redisplacements of the loose surface cartilage with use, is a necessary additional factor, has yet to be determined. This case supports the traumatic theory of origin suggesting that subchondral fracture, with incomplete separation, followed by continued movement of the damaged surface, produces the typical changes within a period of six months.

# SUTURE OF THE EXTERNAL AND INTERNAL POPLITEAL NERVES

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IN an ideal nerve suture, healthy axons with their surrounding Schwann sheaths are approximated without tension to the corresponding distal Schwann tubes. In dealing with war wounds such ideal conditions are rarely attained. Accordingly, the more important factors which may impair the result are listed below.

1 Extensive destruction of the nerve, causing undue tension (Higbet and Holmes, 1943, and Higbet and Sanders, 1943)

2 Extensive fibrosis and degeneration of the nerve consequent upon either infection and/or ischaemia, here again the necessary resection of abnormal tissue may lead to too large a gap and excessive tension, or alternately the mobilization of the nerve necessary to bridge the gap may interfere with its blood-supply. A number of workers (for summary, see Adams, 1943) have investigated the blood-supply of peripheral nerves. It seems agreed that most nerves have both a longitudinal and segmental blood-supply which anastomoses freely and that in the experimental animal both supplies must be occluded before ischaemic changes occur in the nerve. This is *prima facie* evidence that wide mobilization of a nerve may be performed without impairing the blood-supply, and clinical experience confirms this. Nevertheless, some nerves, e.g., the ulnar and external popliteal, seem to be less generously supplied at certain levels and, especially with extensive war wounds, wide mobilization seems to impair further an already scarcely adequate blood-supply.

3 With the mere passage of time the distal Schwann tubes may shrink, thus preventing regeneration of the larger axons (Holmes and Young, 1942, Guttman and Sanders, 1943)

4 The sensory and motor end-organs may atrophy. This will depend on a number of factors—length of time before re-innervation, associated tissue damage, ischaemia, quality and quantity of physiotherapy, etc. It will be noticed that the passage of time may operate in a number of ways: it may indicate infection, extensive tissue destruction, ununited fracture or ischaemia, or it may act *per se* by causing degenerative changes in the nerve or end-organs.

5 Height of lesion. It is obvious that after a high suture it will take longer for peripheral structures to be re-innervated, during the interval various degenerative changes occur (see above), also it is probable that the rate of axonal regeneration becomes progressively slower with the passage of time (Seddon, Medawar, and Smith, 1943). Also a special factor may be operating, e.g., important blood-vessels may enter the nerve at a certain level, a lesion at this level would be likely to cause nerve ischaemia.

6 The inherent powers of axon regeneration may vary with both the age and general condition of the patient and also with the proximity of the

lesion to the nerve-cell. In this survey the first two variables have been largely eliminated. All cases with impaired general health have been excluded, and the great majority of cases have been healthy males between 18 and 30 years of age.

Finally, the degree of successful apposition may vary. Even when every care is taken to suture the nerve-sheath only, to minimize fibrosis and scar tissue, to tie the sutures with correct tension and to orientate the nerve-ends in relation to each other, it is obvious that perfect apposition of each proximal and distal axon sheath cannot be obtained and that there must be considerable 'shunting' of fibres at the suture line. Indeed, it is remarkable that sutured nerves regenerate as well as they do, presumably axonal branching and 're-education' play an important part.

## RESULTS

The results of suture of internal and external popliteal nerves have been chosen for three reasons—

1 The criteria of recovery are simple. On the motor side it is easier to grade a muscle accurately in the leg than in the arm. Owing to overlap and the complex clinical syndromes that appear, it is harder to express sensory recovery in clear-cut grades, in addition, sensory recovery is unimportant in the external popliteal distribution and the finer modalities of sensation are less important in the foot than the hand, so I have omitted sensory recovery in this series.

2 During its course down the thigh, the sciatic nerve only gives off one relatively unimportant branch. Accordingly it is easier to compare the results of 'high' and 'low' lesions than it is to compare above- and below-elbow lesions in the arm.

3 There is a marked difference in results between the external and internal popliteal nerves (Tables I, II).

The mode of assessment has been purely clinical. In no case in this series have the distal muscles regained voluntary contraction, accordingly all recoveries would fall into Group M (1) in the Medical Research Council Scheme of grading, but within this group there are important differences which I have classified in the subgroups 'slight', 'fair', and 'good'.

'Slight' implies a voluntary contraction which is not strong enough to produce movement.

'Fair' implies that the muscles can produce movement.

'Good' implies that the external popliteal muscles can dorsiflex and evert the foot against gravity and that the patient can dispense with all appliances. In the case of the internal popliteal muscles it implies that the patient can stand on tip-toe.



# SUTURE OF POPLITEAL NERVES

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Table I—RESULTS OF EXTERNAL POPLITEAL NERVE SUTURE (59 cases)

CASE	LEVEL OF LESION	GAP BETWEEN NERVE-ENDS AFTER RESECTION	DELAY BETWEEN INJURY AND SUTURE	RESULT
+ L B	Middle	cm 5.5	mths 7	Fair
E B	Popliteal	8.0	14	Slight
H B	Popliteal	?	1	Slight
E B	Popliteal	6.5	10	Nil
- T B	Upper	10.0	12	Nil
R A B	Lower	?	7	Nil
+ J W B	Lower	12.5	5	Nil
+ J B	Middle	7.0	3	Nil
+ G C	Upper	?	2	Nil
L C	Middle	7.5	4	Fair
E C	Lower	5.0	2	Fair
J C C	Lower	6.0	4	Fair
G D	Upper	7.0	5	Nil
J D	Upper	3.0	12	Nil
- A C F	Upper	8.0	7	Nil
K F	Upper	7.0	5	Slight
+ K G	Upper	4.0	2	Nil
+ F G	Lower	6.0	6	Nil
J G	Lower	6.5	6	Slight
J G	Popliteal	5.5	6	Slight
W G	Upper	5.5	10	Nil
+ E H	Middle	7.0	6	Nil
J H	Popliteal	6.0	10	Nil
C H	Popliteal	5.5	8	Fair
W H	Middle	5.5	9	Nil
L H	Popliteal	5.5	3	Good
+ D G J	Upper	7.0	5	Nil
W N J	Lower	4.0	3	Fair
S K	Popliteal	4.5	6	Fair
P L	Upper	5.0	6	Nil
L L	Lower	10.0	7	Nil
J M	Middle	4.0	5	Nil
L McD	Middle	7.0	9	Slight
+ G McL	Middle	6.25	7	Slight
J M	Popliteal	5.0	7	Fair
J McD	Upper	6.0	2	Nil
J F M	Lower	7.0	6	Nil
F N	Lower	2.5	3	Fair
O	Upper	7.5	9	Nil
P	Lower	5.0	4	Nil
+ A P	Lower	5.0	10	Slight
R P	Lower	3.75	7	Fair
J R	Upper	7.0	9	Nil
H R	Middle	5.0	9	Nil

'Upper', 'Middle', 'Lower', and 'Popliteal' stand for upper, middle, and lower thirds of thigh and the popliteal space. From the list of possible variables, three factors have been selected—namely, height of suture, delay in suture, and length of resection. Other factors such as degree of apposition, amount of physiotherapy, the patient's adaptability and powers of re-education, have not easily lent themselves to measurement.

## DISCUSSION

From Table III it will be seen that in the case of the external popliteal, the low sutures give much better results than the high ones. Indeed, all the 'good' results are from sutures performed in the popliteal space, all the 'fair' results are from sutures in the lower third of the thigh or below except for two, in both of which the length of nerve resected was very small.

From Table IV it will be seen that there is little if any difference in the results of suture of the internal popliteal nerve at different levels.

Table V shows that an excessive gap in the nerve is an adverse factor, the results of 'less than 6 cm' resections are distinctly better than '6 cm or over'. All fair and good results occurred following less than 6 cm resection with the exception of three, which were all very low in the thigh.

Table VI expresses the same fact in a slightly different way. Tables VII and VIII, which give comparable figures for the internal popliteal nerve, give similar results but much less marked. Table IX gives the average delay between injury and suture, and shows that the better results are

Table I—continued

CASE	LEVEL OF LESION	GAP BETWEEN NERVE-ENDS AFTER RESECTION	DELAY BETWEEN INJURY AND SUTURE	RESULT
J R	Popliteal	2.5	5	Good
T R	Lower	4.5	8	Nil
J S	Popliteal	?	6	Good
H S	Popliteal	3.0	6	Good
+ W E S	Lower	?	2	Fair
W S	Upper	7.5	13	Slight
H T	Middle	11.0	4	Nil
T T	Popliteal	6.5	8	Nil
+ W T	Upper	4.5	6	Fair
W T	Lower	7.0	6	Nil
L W	Upper	4.0	7	Nil
+ T W	Lower	8.7	8	Fair
+ A W	Upper	9.0	5	Nil
F W	Middle	5.5	3	Nil
+ H W B Y	Middle	?	4	Slight

+ indicates a combined lesion of both nerves

Table II—RESULTS OF INTERNAL POPLITEAL NERVE SUTURE (31 cases)

CASE	LEVEL OF LESION	GAP BETWEEN NERVE-ENDS AFTER RESECTION	DELAY BETWEEN INJURY AND SUTURE	RESULT
R A	Middle	cm 9.0	mths 7	Nil
+ L B	Middle	5.5	7	Fair
+ T B	Upper	10.0	12	Nil
+ J W B	Lower	12.5	5	Fair
+ J B	Middle	8.0	3	Nil
+ G C	Upper	?	2	Fair
+ L C	Middle	11.0	4	Nil
+ J C C	Lower	5.0	4	Fair
T D	Popliteal	8.0	3	Nil
+ A C F	Upper	7.0	7	Nil
+ F G	Lower	8.0	6	Slight
+ K G	Upper	4.0	2	Nil
+ E H	Middle	7.0	6	Fair
+ D G J	Upper	10.5	6	Nil
+ J McD	Upper	6.0	2	Fair
+ G McL	Middle	6.25	5	Good
V A M	Upper	8.0	7	Nil
D O D	Lower	5.5	10	Slight
+ A O	Upper	7.5	9	Slight
F S	Middle	5.5	6	Fair
+ W E S	Lower	?	2	Good
T S	Middle	6.0	6	Nil
W S	Upper	7.5	13	Fair
R T	Upper	3.5	2	Fair
H T	Middle	11.0	4	Slight
G W	Middle	9.0	6	Fair
L W	Upper	4.0	8	Nil
- A W	Upper	9.0	5	Fair
- T W	Lower	6.0	8	Fair
- H W B Y	Middle	?	4	Fair
- W T	Lower	8.5	9	Nil

+ indicates a combined lesion of both nerves

Table III—ANALYSIS OF RESULTS FOR EXTERNAL POPLITEAL NERVE CLASSIFIED ACCORDING TO LEVEL OF LESION

Level	Results
Upper 17 cases	14 nil, 2 slight, 1 fair*
Middle 12 cases	7 nil, 3 slight, 2 fair
Lower 17 cases	8 nil, 2 slight, 7 fair
Popliteal 13 cases	3 nil, 3 slight, 3 fair, 4 good

\* Gap of only 2.5 cm

Table IV—ANALYSIS OF RESULTS FOR INTERNAL POPLITEAL NERVE CLASSIFIED ACCORDING TO LEVEL OF LESION

Level	Results
Upper 12 cases	6 nil, 1 slight, 5 fair
Middle 11 cases	4 nil, 1 slight, 5 fair, 1 good
Lower 7 cases	1 nil, 2 slight, 3 fair, 1 good
Popliteal 1 case	1 nil (large gap)

Table V—RESULTS FOR EXTERNAL POPLITEAL NERVE CLASSIFIED ACCORDING TO GAP AFTER RESECTION (53 cases)

6 cm or over 27 = 18 nil, 6 slight, 3 fair  
 Under 6 cm 26 = 12 nil, 2 slight, 9 fair, 3 good

Table VI—RELATION IN EXTERNAL POPLITEAL NERVE OF RESULT AND GAP AFTER RESECTION

Average length of resection for all cases (53) = 6.1 cm  
 Average length of resection for 'nil' (30) = 6.6 cm  
 Average length of resection for 'slight' (8) = 6.6 cm  
 Average length of resection for 'fair' (12) = 5.2 cm  
 Average length of resection for 'good' (3) = 3.66 cm

Table VII—RESULTS FOR INTERNAL POPLITEAL NERVE CLASSIFIED ACCORDING TO GAP AFTER RESECTION

6 cm or over (21) = 10 nil, 3 slight, 7 fair, 1 good  
 Under 6 cm (6) = 2 nil, 1 slight, 4 fair

Table VIII—RELATION IN INTERNAL POPLITEAL NERVE OF RESULT AND GAP AFTER RESECTION

Average length of resection for all cases (28) = 7.3 cm  
 Average length of resection for 'nil' (12) = 7.5 cm  
 Average length of resection for 'slight' (4) = 8.0 cm  
 Average length of resection for 'fair' (11) = 6.95 cm  
 Average length of resection for 'good' (1) = 6.25 cm

Table IX—RELATION OF DELAY BEFORE SUTURE TO RESULT IN EXTERNAL POPLITEAL NERVE

Average delay for whole series (59) = 6.2 mths  
 Average delay for 'nil' (32) = 6.5 mths  
 Average delay for 'slight' (10) = 7.5 mths  
 Average delay for 'fair' (13) = 4.7 mths  
 Average delay for 'good' (4) = 5 mths

Table X—RELATION OF DELAY BEFORE SUTURE TO RESULT IN INTERNAL POPLITEAL NERVE

Average delay for whole series (31) = 5.9 mths  
 Average delay for 'nil' (12) = 6.3 mths  
 Average delay for 'slight' (4) = 7.2 mths  
 Average delay for 'fair' (13) = 5.4 mths  
 Average delay for 'good' (2) = 3.5 mths

associated with a shorter interval. A similar table for the internal popliteal (Table X) gives similar results, but less clear-cut.

Table XI shows the result of combined suture of both nerves, and it is obvious that the internal popliteal nerves shows a higher number of recoveries although the conditions were strictly comparable.

Table XI—COMPARISON OF RESULTS OF INTERNAL AND EXTERNAL POPLITEAL NERVES, WHERE BOTH NERVES HAVE BEEN SUTURED SIMULTANEOUSLY

Internal popliteal 7 nil, 2 slight, 9 fair, 2 good } 20 cases.  
 External popliteal 12 nil, 2 slight, 6 fair, 0 good }

There are three observations which have a bearing on this. Firstly, the external popliteal is more vulnerable than the internal, for example, following a through-and-through wound of the thigh passing close to the sciatic nerve, it is common to find a complete lesion of the external popliteal nerve, but practically no damage to the internal popliteal. Secondly, at operation it is common to find extensive atrophy of the external popliteal nerve, thirdly, it is a common observation that the cut ends of this nerve are relatively avascular. It is suggested that the blood-supply is less adequate (Paterson Ross, 1945) and that because of its inherently smaller powers of regeneration the various adverse factors—a high lesion, an extensive gap, or long delay—have a greater effect than in the case of more vascular nerves. A similar comparison may

be made between the median and the ulnar nerves—the latter is often subjected to extensive mobilization and is relatively avascular and often atrophic and yields less good results. It is interesting to note that the relatively vascular median and internal popliteal nerves are more often associated with the syndrome known as causalgia.

### SUMMARY

The results of suture of the external and internal popliteal nerves have been analysed.

In the case of the external popliteal, a high lesion, a long delay, and a large gap are considered to be adverse factors. These factors have a less marked effect in the case of the internal popliteal nerve, probably owing to its greater inherent powers of regeneration, which may be related to its greater vascularity.

I would like to thank Professor Platt for advice and criticism, also Messrs R Barnes, C H Cullen, and A S Kerr for allowing me access to cases on which they have operated.

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## HÆMATEMESIS FROM EROSION OF THE SPLENIC ARTERY BY PEPTIC ULCERATION

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OF those vessels whose erosion by peptic ulcer may occasion massive hæmatemesis, the splenic artery is the most notorious source of rapidly fatal hæmorrhage. Erosion of the aorta or of the heart leads to even more dramatic hæmorrhage, but bleeding from these so rarely complicates peptic ulceration that they cannot compare in importance with the splenic artery as sources of hæmatemesis. Surgical arrest of hæmorrhage from the splenic artery is possible only if circumstances of time and place combine in a peculiarly favourable way, and if the tempo of the hæmorrhage does not outpace that of blood transfusion and of the preparations for operation.

### CASE REPORT

**HISTORY**—On the afternoon of July 19, 1945, Dr A G Badenoch was called to a female patient of 56 years who had collapsed after vomiting a pint of coffee-coloured fluid; he transferred her at once to hospital. There was a twenty-year history of dyspepsia—flatulence, acid eructations, and epigastric pain half an hour after food, relieved by alkalis but not by food. A barium series in 1929 had demonstrated a large ulcer on the lesser curvature and posterior wall of the stomach, but surgical advice had not then been sought. In 1939 there had been a slight hæmatemesis treated medically. The present hæmatemesis had been preceded by two weeks of continuous and disabling epigastric pain.

**ON ADMISSION**—On arrival in hospital the patient was pallid and was sweating; the pulse-rate was 104, the blood-pressure 90/60, and the hæmoglobin level 70 per cent. The hæmatemesis was then regarded as of only moderate degree. Morphine was prescribed and a modified Meulengracht diet was begun.

Improvement followed rapidly, and at noon next day the patient was entirely comfortable; the pulse-rate and hæmoglobin level were unchanged, and the blood-pressure was 130/80. Two hours later, however, a small quantity of red blood was vomited and operation was therefore planned, in conformity with the opinion that intervention is desirable if a patient over 45 years of age, and known to suffer from a peptic ulcer, bleeds

on the day after the commencement of a hæmatemesis. A blood-drip was set up, but as preparations for the operation proceeded, further fresh hæmatemesis occurred. It had been arranged to operate at 5 p.m., a few minutes before that hour a litre of bright and partly coagulated red blood was vomited. The transfusion rate was accelerated to a rapid continuous flow, but even a rate of 150 c.c. a minute could not apparently keep pace with the speed of blood-loss and the patient rapidly became pulseless.

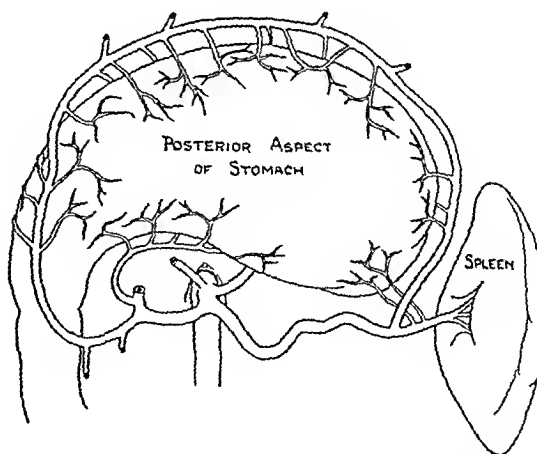


FIG 449—Blood-supply of spleen before operation

**FIRST OPERATION (July 19)**—Under light gas and oxygen anaesthesia (Dr F G Gibbs) the abdomen was opened by a median supra-umbilical incision. The crater of a large ulcer was felt on the posterior wall of the stomach, midway between the curvatures and a hand's-breadth to the left of the median plane. The stomach was opened between stay sutures in its anterior wall, whereupon some 400 c.c. of bright red blood overflowed from its lumen. The stomach was emptied by suction, but arterial blood spurted from the depths of the ulcer so vigorously that it could not be stayed even

by a thumb thrust into the crater, the ulcer, though palpably fixed to the pancreas, slid away in a curiously elusive fashion between the operator's thumb and the posterior abdominal wall. When, however, a tissue forceps was applied to the gastric mucosa beyond the ulcer and drawn forwards into the wound, the crater was steadied on the tip of the compressing thumb like the apex of a bell-tent on its pole, and bleeding temporarily

smooth, glistening, and indistinguishable in texture from the neighbouring peritoneum of the posterior abdominal wall. In the substance of the pancreas, deep to the floor of the ulcer, could be seen a white puckered scar, approximately 1.5 cm in diameter. The sutured ulcer had reopened, but the excavation of the pancreas had healed. The remainder of the pancreas was of a normal appearance and consistence. No pulsation could be felt along

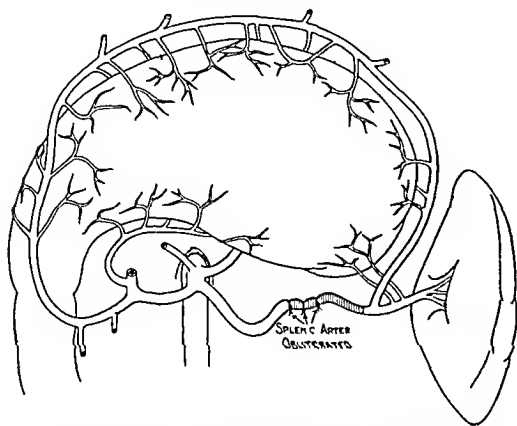


FIG 450—Blood supply of spleen, after obliteration of the main trunk of the splenic artery, showing collateral supply by left gastro epiploic and short gastric arteries

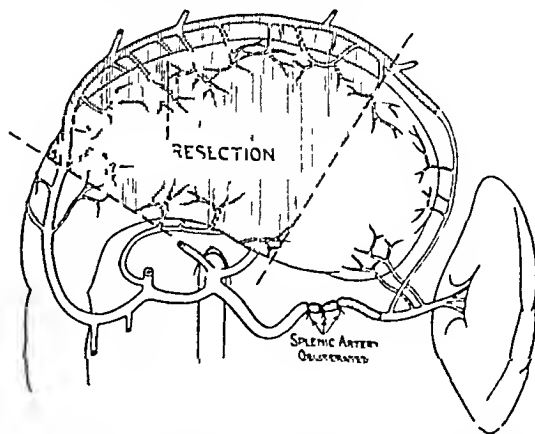


FIG 451—Blood supply of spleen after second operation of gastrectomy, showing dependence on a collateral supply through short gastric branches only

ceased. At this point a pause was made for blood-replacement to overtake blood-loss.

It was obvious that the source of hæmorrhage was the main trunk of the splenic artery. A series of deep catgut sutures were inserted in the sagittal plane, through stomach wall above and below the ulcer, and through a substantial thickness of pancreas. Only when four of these sutures were tied was the bleeding sufficiently controlled for digital compression to be relaxed. A few further sutures were inserted to obliterate the crater completely, and the stomach and abdomen were closed. It was assumed from the depth of penetration of these sutures that they occluded both splenic artery and splenic vein.

**PROGRESS**—Blood transfusion, continued as a steady flow until the bleeding was controlled, was maintained thereafter at forty drops per minute during the succeeding night, to a total amount of three litres. Nasal suction drainage of the stomach and intravenous administration of saline and dextrose solutions were continued for seventy-two hours. The patient's condition improved steadily after operation, no fresh hæmorrhage occurred, and a progressive diet was well sustained after the third day, but the temperature swung daily from 99° to 102° F for seven days after operation, and for ten days complaint was made of cramping, prostrating, median epigastric pain, greater than any previously produced by the ulcer, and penetrating to the middle of the back. There was no pain in left side or shoulder, and no evidence of pancreatic insufficiency. The patient returned home on the thirty-third day after operation.

**SECOND OPERATION**—At subtotal gastrectomy, performed on Oct 20, the antrum and body of the stomach were removed, together with the vessels on both curvatures. The lesser sac was found almost completely obliterated. The same or a similar ulcer was present on the posterior surface of the stomach, in the same site and of the same size as at the previous operation, but appreciably less deep. As a step in its removal the stomach was separated from the floor of the ulcer by an incision around the circumference of the ulcer, so that the floor was left undisturbed, and a circular defect remained at the ulcer site on the posterior wall of the ablated stomach. The ulcer floor was then seen to be

the line of the supra-pancreatic portion of the splenic artery, but the spleen was of average size, colour, and consistence, and apparently free from infarction.

The patient's recovery from gastrectomy was uneventful, and again there were no symptoms of splenic infarction; she has now resumed the diet of a healthy person. The platelets on Jan 2, 1946, numbered 700,000 per c mm.

## SUMMARY AND CONCLUSIONS

- 1 Hæmorrhage from a splenic artery eroded by a peptic ulcer need not immediately threaten life, as in the case of bleeding from the other arterial trunks which are subject to erosion, a massive hæmorrhage may be heralded by lesser hæmorrhages.

- 2 A favourable combination of circumstances may permit the surgical control of hæmorrhage from a splenic artery eroded by a peptic ulcer.

- 3 An intragastric manœuvre is described which facilitates digital control of hæmorrhage from an eroded splenic artery, as soon as digital control is assured, further operative procedures can be suspended until blood-replacement has overtaken blood-loss.

- 4 Sutures inserted in emergency through the posterior stomach wall in the neighbourhood of an active ulcer, and beyond that deeply into the substance of the pancreas, produce severe post-operative pain; they do not appear to cause pancreatic œdema of a dangerous degree.

- 5 Obliteration of the splenic artery in its supra-pancreatic course is not necessarily followed by infarction of the spleen. The signs of infarction did not appear even after gastrectomy interrupted the collateral supply along the greater curvature and left the spleen dependent on the short gastric vessels, certainly for arterial supply, and probably for venous drainage as well.

## THE SURGICAL TREATMENT OF SEVERE EPISTAXIS IN RELATION TO THE ETHMOIDAL ARTERIES

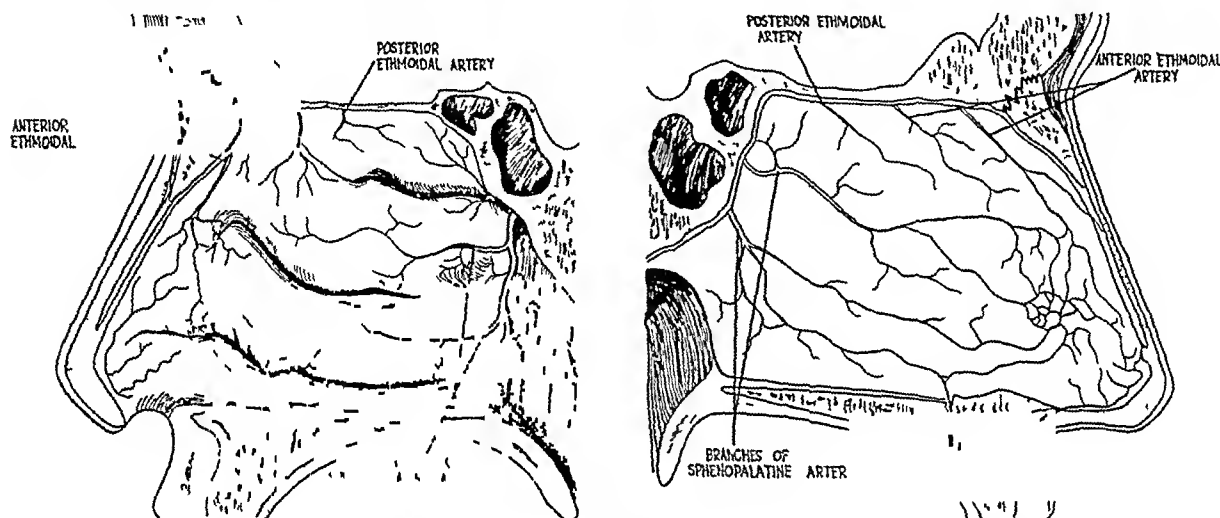
By G WEDDELL, R G MACBETH, H S SHARP, AND C A CALVERT

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SEVERE epistaxis is a relatively common emergency, which the otolaryngologist is called upon to treat. Local measures usually suffice to stop the bleeding, but in a few cases (particularly those following skull injuries or nasal operations), it is necessary to consider ligation of a main artery of supply.

The purpose of this paper is to describe the blood-supply of the nasal mucous membrane in relation to the surgical control of severe epistaxis, and in addition to describe 7 cases of epistaxis in which the bleeding was not controlled until the

The arteries from which bleeding occurs in cases of epistaxis are not necessarily large vessels, but they lie in regions where they may easily suffer either mural injury or laceration. In addition, the tissue in which they are embedded is such that contraction and retraction of the vessels is relatively impeded, and thus the spontaneous arrest of hæmorrhage cannot so readily take place as it does elsewhere. Secondary hæmorrhage also may readily occur from these vessels in the presence of nasal sepsis.



FIGS 452, 453—The arteries supplying the nasal mucous membrane (After Zuckerkandl)

blood-flow through the ethmoidal arteries on the affected side had been interrupted. It is not our purpose to discuss either the aetiology or local treatment of nasal hæmorrhage.

### THE BLOOD-SUPPLY OF THE NASAL MUCOUS MEMBRANE IN RELATION TO EPISTAXIS

The blood-supply of the nasal cavities was described in some detail by Zuckerkandl in 1885. His observations were based on the study of a number of specimens in which the blood-vessels had been injected. He states that the largest source of supply is from the sphenopalatine artery, but that the facial and the anterior and posterior ethmoidal arteries also contribute to the arterial network which supplies the interior of the nose. The sphenopalatine and facial arteries are derived from the external carotid artery, while the ethmoidal arteries are branches of the ophthalmic artery which springs from the internal carotid artery. The relative sizes, average positions, and areas covered by the arteries supplying the nasal mucous membrane, are given in Figs 452, 453. These figures are based on the description by Zuckerkandl.

The branches from the sphenopalatine and facial arteries enter the nasal cavity through its lateral walls. Here, in the event of rupture or laceration, they are comparatively easy of access through the anterior nares, and hæmorrhage, although usually checked by packing or coagulation, may in certain instances be controlled under vision by ligation (Rosenfold, 1940). In some cases, owing to distortion of the nasal cavities occasioned by maldevelopment, injury, or disease, local measures may not be effective. In such an event, ligation of the external carotid artery on the affected side, in addition to local measures, has been considered the logical method of controlling the hæmorrhage. Johnson and Foster (1933) and Barker (1943) have reported instances in which such treatment was successful, and many other otolaryngologists will have had similar cases in their own experience. However, in some instances even ligation of the external carotid artery has failed to control the bleeding satisfactorily, and Hirsch (1936), among others, has advocated ligation of the internal maxillary artery in the sphenomaxillary fossa. Ligation in this position is said to circumvent the possibility of blood reaching the open vessel through anastomoses between the external carotid arteries across

the midline. The vessel is approached through the maxillary antrum, and the operation is described as being easy technically and can be performed quickly under local anaesthesia.

It is interesting, nevertheless, that severe bleeding from the nose which occasionally follows the operation of antrostomy, and which must involve branches of the sphenopalatine artery, is always successfully controlled by ligation of the external carotid artery.

The ethmoidal arteries pass into the nasal cavities through their roof. They are thus more difficult of access through the anterior nares, for not only are they some distance upwards and backwards from the nostrils, but the olfactory cleft is narrow in this position. Thus, in the event of their rupture

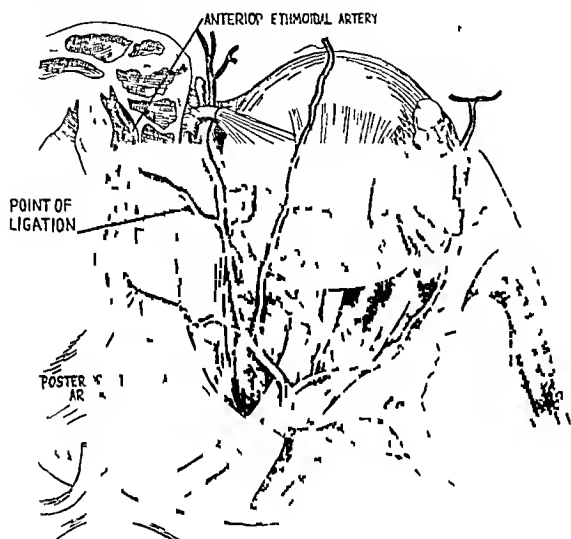


FIG. 454.—Showing the point of ligation of the anterior ethmoidal artery and the anatomy of the region (After Poirier)

or laceration (following injuries or operations in the region of the upper or middle concha), the control of hæmorrhage under vision or by packing is often difficult. In addition, in an injury which causes severe epistaxis, it is common for either the nasal or ethmoidal bones to be fractured, a condition which tends to increase still further the inaccessibility of the ethmoidal arteries. Ligation of the external carotid artery, although diminishing the total blood-flow through the arterial network in the nasal mucous membrane, does not usually control the bleeding in such cases, and the next procedure advocated by most text-books is to tie the common carotid artery. It is true that except in very rare instances in which the ophthalmic artery springs from the external carotid artery (Adachi, 1938), the ethmoidal arteries derive their blood from the internal carotid artery. However, ligation of this vessel will not, in the majority of cases, control hæmorrhage from the ethmoidal arteries, owing to the anatomical efficiency of the circle of Willis. Adachi notes the absence of an anterior communicating artery only four times in 1653 dissections, and states that it may even be duplicated. In addition to anatomical evidence of the free anastomoses between the internal carotid

arteries at the base of the brain, Schorstein (1940) has shown that the circle of Willis is very efficient from the clinical point of view. But, apart from the doubtful value of ligating the common carotid artery to control hæmorrhage from the ethmoidal arteries, such a procedure is not without danger, for Schorstein has also demonstrated that, although the collateral circulation is adequate under normal intracranial circulatory conditions, in the presence of anæmia due to hæmorrhage serious cerebral damage may ensue.

Clearly, the logical method of controlling hæmorrhage from the roof of the nasal cavities is by interrupting the flow of blood through the ethmoidal arteries themselves. They can be exposed in the orbit shortly after they spring from the nasal branch of the ophthalmic artery (Figs 454, 455). The operation is an easy one and can be performed in a few minutes under local anaesthesia.

These anatomical facts do not appear to have been appreciated, for in no instance, either in current English or American text-books, is ligation of the ethmoidal arteries mentioned in connexion with the control of epistaxis, although ligation of the common carotid is recommended if ligation of the external carotid artery and local measures together are unsuccessful.

In the absence of any clear teaching on the subject of the surgical control of epistaxis, it has become traditional to ligate first the external, then the common, carotid artery in desperate cases. In a large number of instances this line of treatment is successful. In some cases this success must clearly have been because the correct artery was tied, in others, it is quite probably due to the combination of a diminution of the blood-flow following carotid ligation, local packing, and the administration of sedatives in sufficient doses to keep the patient quiet for a sufficient period after operation.

It is surprising that this state of affairs still exists, for ligation or coagulation of the ethmoidal arteries is a well-recognized step in the course of operative procedures in the neighbourhood of the ethmoidal air cells, and Davis (1939) describes a fatal case of epistaxis due to traumatic rupture of an anterior ethmoidal artery in which he says that life would have been saved had the artery been ligated in the orbit. Moreover, attention has been drawn to the possible value of ligation of the anterior ethmoidal artery in cases of intractable epistaxis by Goodyer (1937) and by Reading (1945), who each describe a single case in which a cure was effected by this simple procedure.

In rare instances severe epistaxis may result from rupture of an intracranial aneurysm into an accessory air sinus (Griffiths, 1915; Birley and Trotter, 1928; and Davis, 1939). Ligation of the common carotid artery on the affected side is the only treatment of any value in such cases. If there is any doubt as to the presence of an intracranial aneurysm, and the patient's condition allows of it, an arteriogram can always be performed before carotid artery ligation and the diagnosis established.

## CASE REPORTS

In the case reports which follow, the primary causes of the epistaxis were injury (Cases 1-4),



# SURGICAL TREATMENT OF SEVERE EPISTAXIS

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hyperpiesis (Cases 5 and 7), and telangiectasis of pregnancy (Case 6)

**Case 1**—Dvr W K, aged 23, was struck over the bridge of the nose by a heavy metal staple on Sept 2, 1943. His nose bled so severely that the right nostril had to be packed at a Camp Reception Station. This was a trickle of blood coming from the posterior nares. He was therefore sent to a Military Hospital for X-ray examination, and this showed a fracture of the nasal bones with dislocation to the left and backwards. The packing was changed and the bleeding ceased, but he was kept at the Camp Reception Station for six days as a precautionary measure.

On the sixth morning after the accident he was allowed up, and the nasal packing was removed. At 5 p.m. the bleeding recurred and the right nostril was repacked. This was only partially effective, for blood continued to trickle from the posterior nares.

Next day he was pale and restless. During examination, it was elicited that he was subject to headaches of migrainous type, and this raised the possibility that the nasal haemorrhage was due to a ruptured intracranial aneurysm leaking into one of the nasal air sinuses. He was, therefore, transferred to a Military Hospital for Head Injuries.

On admission, examination of the nose revealed that blood was coming from above the middle concha on the right side, but it was not possible to localize its origin more accurately. The nostril was packed with gauze soaked in adrenaline and this appeared to control the bleeding, next morning, however, it recommenced. At this time the blood-count showed 1,500,000 R.B.C.'s and the haemoglobin concentration was 38 per cent.

An arteriogram, rapidly effected under local anaesthesia, proved to be normal, but because carotid compression appeared to control the bleeding, the external carotid was tied. Bleeding, however, continued as before, and the patient was kept alive only by continuous and brisk blood transfusions. A discussion next arose as to whether the cessation of bleeding on compression (in view of the common carotid artery should be tied or whether the simpler and less drastic operation of interrupting the ethmoidal vessels should be tried).

The latter operation was considered to be the most logical step and was therefore carried out. The anterior and posterior ethmoidal vessels were exposed under local anaesthesia, and coagulated with diathermy current. The bleeding ceased immediately and recovery was uninterrupted.

**Comment**—In this case there was proof that the bleeding was coming from an ethmoidal artery. In the light of our subsequent experience in these cases, the site of origin of the bleeding, *above* the middle concha, would have led us to interrupt the ethmoidal vessels as the primary operative procedure. The collateral circulation through the circle of Willis was assumed to be poor in this case, for carotid compression controlled the bleeding. Presumably, therefore, serious cerebral damage might have followed ligation of the internal carotid artery.

**Case 2**—J W, aged 11, was hit on the nose by a 'bumping' cricket ball on May 27, 1944. Five days later he had a severe haemorrhage from the left nostril. The bleeding was controlled by packing. The next day there was another severe haemorrhage, also controlled by packing. He was admitted to hospital on June 3 for observation and had two further minor haemorrhages that night. Examination of the septum revealed no definite bleeding vessel, but a suspicious vein was cauterized. A radiograph showed fractured nasal bones and a slight opacity of the sinuses on the left side. On June 8 he had a massive left-sided nasal haemorrhage, which was controlled by packing. In view of the extent

of the haemorrhage, however, the left external carotid artery was ligated under cervical plexus block anaesthesia. Following this operation, the nasal pack was removed and the bleeding was found to have ceased. Compression of the common carotid artery was not carried out before the operation. On June 11 he had another severe haemorrhage. This was controlled by means of packing in the anterior part of the roof of the nose. In view of this observation it was decided to ligate the anterior ethmoidal artery. This was carried out with stainless steel wire under general anaesthesia. Recovery was uninterrupted.

**Comment**—The nature of the injury should have indicated that the source of the blood was most probably from the anterior ethmoidal artery, and indeed this was confirmed by the fact that a high anterior nasal pack controlled the haemorrhage. This case illustrates the importance of noting the position within the nasal cavity in which packing has to be placed to control the bleeding. Even when the haemorrhage is very profuse, it is possible by this means to locate the approximate site from which the bleeding is coming. The ligation of the external carotid artery must have reduced the blood-flow in the network of vessels supplying the nasal cavity and temporarily controlled the bleeding. It was, however, of no permanent value.

**Case 3**—F/O S, aged 24, was involved in an air crash on Aug 25, 1944. He sustained a head injury, with severe epistaxis. The nasal haemorrhage ceased spontaneously and he made good progress until September 5, 1944, when he had a further profuse haemorrhage from the left nostril. On this occasion, it was estimated that he lost between two and three pints of blood. He was transfused, the nose was packed tightly, and the bleeding ceased. On the next day there was a further severe haemorrhage, but on this occasion it could not be controlled completely by packing. The patient was therefore transfused again and then anaesthetized and the packing removed. Blood was seen to be coming from high up in the region of the olfactory cleft. The nose was repacked, and he was transferred to a Military Hospital for Head Injuries.

On admission he was pale and restless. Radiographs of the skull revealed no fracture and there was no clinical evidence of an intracranial aneurysm. Removal of the nasal packing was followed by severe arterial bleeding, and his condition became critical. He was given a further blood transfusion and the carotid arteries were exposed in the neck. The external carotid artery was ligated, but immediately afterwards the patient expelled his nasal packing during a fit of coughing and the bleeding again became violent. The internal and common carotid arteries on the left side were then tied, but without appreciably diminishing the loss of blood from the nose. Once again, the nostril was packed and he was given a third blood transfusion. No abnormal neurological symptoms or signs followed these procedures.

Next day the nasal packing became loose, he began to bleed again and was only kept alive by continuous brisk blood transfusion. By the following evening he was desperately ill, for by now he was losing blood faster than he was receiving it. It was therefore decided to try the effect of occluding the ethmoidal vessels. This was done under regional block anaesthesia of the first and second divisions of the fifth cranial nerve. The anterior ethmoidal artery and an accessory vessel were occluded. The nasal packing was removed and it was found that the bleeding had ceased. The patient made an uninterrupted recovery.

**Comment**—The source of the bleeding from high up in the olfactory cleft should have suggested that the ethmoidal vessels were implicated. The efficiency of the circle of Willis was shown by the fact that on ligation of the internal carotid artery the bleeding was unaffected, and, although the patient was exsanguinated, he suffered

no neurological complications following ligation of the common carotid artery

**Case 4**—Sgt J H, aged 34, had a severe spontaneous left-sided epistaxis on Nov 23, 1944. His medical officer packed his nose but this did not control the bleeding, so he was transferred to hospital. The packing was removed and this was followed by brisk arterial hæmorrhage. The bleeding came from high up in the nose, but, as the septum was deviated to the left, the bleeding point could not be located precisely. The nose was, therefore, repacked. The next day blood was still trickling from the nose, and removal of the packing was accompanied by a brisk hæmorrhage. The subsequent pack was left undisturbed for two days, nevertheless, slight bleeding continued. On the third day a submucous resection of the septum was carried out in order to localize the bleeding point with greater accuracy. However, it was only possible to confirm that the bleeding was coming from high up in the olfactory cleft. Following the operation the nose was repacked tightly and the patient given a blood transfusion.

Three days later, despite packing, the bleeding again became profuse. The common carotid artery was, therefore, ligated under general anaesthesia. In spite of this, brisk arterial bleeding recommenced from the left nostril when the nasal packing was removed. No abnormal neurological symptoms or signs followed the occlusion of the common carotid artery.

Two days later the patient's condition had become critical, and it was decided to occlude the ethmoidal vessels. The anterior ethmoidal artery was ligated and the posterior coagulated with a diathermy current. When the nasal pack was removed there was no further bleeding and from then onwards the patient's recovery was uneventful.

**Comment**—There was good evidence in this case also that the bleeding was coming from the anterior ethmoidal artery. Unfortunately, compression of the common carotid artery was not carried out before it was ligated. It is of interest that ligation of this artery was not followed by damage to the central nervous system. Cases 3 and 4 lend support to Schorstein's contention that the collateral circulation through the circle of Willis is usually sufficient to prevent cerebral damage following ligation of a common carotid artery.

**Case 5**—J B, aged 12, was struck on the nose by the leg of a chair early in July, 1945, but there was very little bleeding from the nostrils. Four weeks later, however, his left antrum was punctured and washed out because it was infected. On the evening of Aug 14 he was struck a trivial blow on the nose by his sister. A severe epistaxis from the left nostril followed immediately. Medical attention was not sought, for he was camping at the time and no doctor was readily available. First-aid treatment was given, but he apparently lost a considerable quantity of blood during the night. The next day he was admitted to hospital and the first-aid nasal pack was removed. The hæmorrhage was minimal by now, but, nevertheless, an enlarged vein in Little's area was cauterized as a precautionary measure. A severe deviation of the septum to the left was noted. A radiograph of his sinuses showed a fracture into the left frontal sinus, and possibly into the left ethmoidal region, and there was relative opacity of both the left antrum and left ethmoidal region.

Despite the cauterization, slight bleeding recommenced and on Aug 17 it had increased and become bright red. The left anterior ethmoidal artery, therefore, was exposed and occluded under local anaesthesia. The fracture into the frontal sinus involving the vessel was identified during the operation. There was no further bleeding.

**Comment**—In this case the anterior ethmoidal artery was occluded as a primary operative procedure

and was effective. The decision to occlude the artery was based on the position from which the hæmorrhage was proceeding. The sequence of pathological events probably took the following form: fracture through the foramen for the anterior ethmoidal artery, infection within the left sinuses, erosion of the vessel wall, initiation of epistaxis by a trivial injury.

**Case 6**—Mrs C I, aged 30, during the evening of Aug 16, 1945, had a severe hæmorrhage from the right nostril; this was controlled by means of a nasal pack. Twenty-four hours later when the packing was removed, the bleeding recommenced. Another pack was inserted and she was sent into hospital next day, for she had lost a considerable amount of blood. There was no history either of injury or infection. She was six months pregnant; it was her second pregnancy and there had been no epistaxis on the previous occasion. There was a trace of albumin in her urine, but her blood-pressure was not raised, she had no œdema of the ankles or face, and her blood-uric acid level was within normal limits.

Shortly after her admission, the pack was removed and the bleeding recommenced. The blood was seen to be coming from the roof of the right nasal cavity, anteriorly between the septum and the middle concha. The precise origin of the bleeding could not be determined, however, owing to a deviation of the septum towards the right. The nasal mucous membrane was covered with a paste containing 25 per cent cocaine and desiccated suprarenal gland, and a cotton-wool pack was inserted into the nostril. Bleeding ceased in a few minutes and the septum was then cauterized as high up as possible above the middle concha.

A small quantity of blood continued to pass down the pharynx for the next four days until, on Aug 22, another massive hæmorrhage occurred. By this time her erythrocyte count had dropped to 1,800,000 and she was given a transfusion of two pints of blood. The bleeding was again controlled by packing, but, in view of her condition, it was decided to occlude the right anterior ethmoidal artery. This was carried out under local infiltration anaesthesia, and when the nasal packing was removed the bleeding did not recur.

**Comment**—In this case also the anterior ethmoidal artery was occluded as the primary surgical procedure and effected a cure. Telangiectasis of pregnancy is a recognized disease, and in the absence of injury or sepsis it is presumed that this patient had such a condition high up in the right olfactory cleft.

**Case 7**—G B-T, aged 62, on Jan 12, 1946, had a sudden profuse epistaxis from the left nostril while repairing a wheel of his car. He lay down and it stopped after there had been a considerable loss of blood. Next day he had another large hæmorrhage, which was controlled by packing. The following night there was some oozing, and when the packing was removed the bleeding again became profuse. This was controlled by further packing, but he vomited on his way to hospital and the bleeding recurred.

On arrival at hospital the bleeding again became profuse when the pack was removed. The source of the bleeding was anterior and superior to the middle concha. The bleeding was controlled by a pack of cotton-wool covered with 25 per cent cocaine paste inserted into this region.

The patient's general condition was fair, but the percentage of hæmoglobin had fallen to 38. Accordingly, the anterior ethmoidal artery was interrupted with two silver clips under local infiltration anaesthesia. The vessel, it was noted, was larger than usual.

The following morning the patient had another considerable hæmorrhage, which came from the region supplied by the anterior ethmoidal artery. The wound was reopened, the vessel was ligated with a stainless

steel wire and coagulated with a diathermy current through the wire. In addition, the posterior ethmoidal artery, which was very small, was also coagulated. There was no further bleeding.

**Comment**—In this case the bleeding was associated with hyperplasia, and was arising from the area supplied by the anterior ethmoidal artery. Packing only temporarily controlled the bleeding. The failure of the first operation was due either to the fact that the anterior ethmoidal artery was duplicated, and the silver clips not applied to both vessels, or to the fact that the posterior ethmoidal artery was responsible for the hæmorrhage. In our opinion, the former is more likely, for the posterior vessel was so small. Complete occlusion of the vessels, as in our previous cases, stopped the bleeding.

### OPERATIVE TECHNIQUE

**Anæsthesia**—Local infiltration of procaine or nupercaine and adrenaline is the method of choice, for it is quick and less complicated than regional block anæsthesia. General anæsthesia is contra-indicated because of the danger of aspiration of blood into the lungs.

The skin over the bridge and side of the nose on the affected side is infiltrated, first intradermally, and then subperiosteally, with a 1-in 21-gauge needle. A 2-in needle of the same gauge is then substituted and the medial wall of the orbit infiltrated subperiosteally. It is important that the needle point should be in contact with the bone throughout, to avoid injecting fluid into the orbit itself, and it should be directed so as to infiltrate above and below the point of entry of the ethmoid vessels into the nasal cavity.

EXPOSURE OF ANTERIOR ETHMOIDAL ARTERY

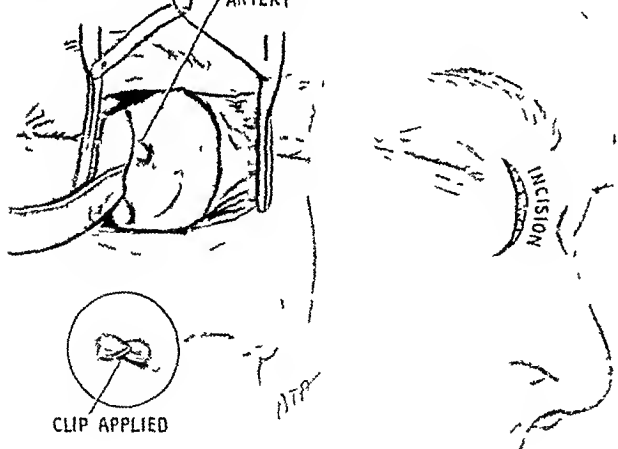


FIG 455—Exposure of the anterior ethmoidal artery

**Operation**—A curved 1½-in incision, with its centre situated medial to the inner canthus of the eye, is employed, and is carried to bone. The periosteum is incised and elevated from above downwards and backwards to a depth of about 1½ in from the bridge of the nose, when the ethmoidal vessels will be seen passing in a cuff of connective tissue to the foramen in the suture line between the frontal and ethmoid bones along the inner wall of the orbit. The vessels are easily defined (Fig 455), after which a malleable metal retractor is placed beneath the periosteum and the

orbital contents retracted gently outwards and downwards. Ligation is relatively difficult in this situation, so that a silver clip has usually been employed to interrupt the anterior ethmoidal artery. The posterior ethmoidal vessel or vessels are usually small and can be coagulated with a high-frequency diathermy current. This manœuvre requires care, for the optic nerve is only a very short distance behind the posterior ethmoidal arterial foramina. If the skin edges are carefully approximated the resulting scar is practically invisible.

### DISCUSSION

Epistaxis may result from the rupture or laceration of branches of the external carotid artery or of the ethmoidal arteries. This statement is supported by anatomical and clinical considerations. If the hæmorrhage originates from an ethmoidal artery, we have demonstrated that it cannot be effectively controlled by ligating either the common, the internal, or the external carotid artery.

It has been recommended by Hirsch (1936) that the internal maxillary artery should be ligated in preference to the external carotid artery, for he has stated that failure to control epistaxis by carotid ligation is due to anastomoses between the external carotid arteries across the midline. On the other hand, our experience, particularly in the cases reported, suggests that failure of carotid ligation is due to direct leakage from the ethmoidal arteries. Furthermore, it is our belief that ligation of the internal maxillary artery is a difficult, dangerous, and unnecessary procedure. We believe that ligation of the common carotid artery is never justifiable for the control of epistaxis, unless this is due to a ruptured intracranial aneurysm leaking into an accessory air sinus.

We recommend that in cases of severe epistaxis diagnosis and treatment should proceed along the following lines. It must first be determined whether the bleeding is coming from above or below the middle concha. In cases where the hæmorrhage is profuse, the approximate source can be determined by observing the effect of packing different regions of the nasal cavity. Digital pressure on the common carotid artery may be used as an additional aid. If the compression does not arrest or conspicuously diminish the hæmorrhage, this would strongly suggest that it originates from an ethmoidal artery.

The approximate source of the bleeding having been determined, local measures such as packing should be instituted. If local measures fail, then either the external carotid or ethmoidal arteries should be occluded under local anæsthesia, depending on the source of the hæmorrhage.

### SUMMARY

1 The blood-supply of the nasal mucous membrane has been discussed in relation to the surgical control of epistaxis.

2 Seven cases of epistaxis have been reported in which the hæmorrhage was not controlled until the ethmoidal arteries on the affected side had been occluded. In three of the cases reported the ethmoidal arteries were occluded as the primary and only surgical procedure.

3 The anatomical approach to the surgical treatment of epistaxis has been discussed

The authors' thanks are due to Mrs M Clark for preparing the illustrations for Figs 452-454 and to Miss A Arnott for the drawing of Fig 455

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### SHORT NOTES OF RARE OR OBSCURE CASES

## RETROGRADE INTUSSUSCEPTION OF LESSER CURVATURE OF STOMACH, PYLORUS, AND FIRST PART OF THE DUODENUM INTO THE ŒSOPHAGUS

BY J LANNON AND A CULINER

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APART from pyloric stenosis, surgical conditions of the stomach are rarely found in infants. This case is an example of a retrograde intussusception into the lower œsophagus of the lesser curvature, pylorus, and the first part of the duodenum. It is recorded because of the unusual nature of the findings and the absence of any reference to a similar condition in the available literature.

#### CASE REPORT

This 10-months-old child had been admitted to hospital because of malnutrition. The records reveal that the child was markedly dehydrated, had a temperature of 103° on admission, and despite feedings went rapidly downhill until death five days after admission. X rays revealed a markedly dilated, globular stomach. No further clinical information was available.

Post-mortem examination (Figs 456-458) showed that the stomach (S) was globular in shape and about 6.5 cm in diameter. The pylorus and first part of the duodenum were not visible anteriorly. Extending from the right



FIG 456—Showing dilatation of œsophagus in relation to diaphragm and aorta. A, Thoracic aorta, D, Diaphragm, O, Œsophagus, L, Liver, Om, Attachment of omentum, S, Stomach.

of the œsophageal opening above, to the spleen on the left below, an oblique attachment to the stomach of the greater omentum was observed (Om). There was no connexion between this membrane and the transverse colon, except at its splenic extremity.

From the transverse colon, the mesocolon, triangular in shape, extended and was attached by its apex to the first part of the duodenum. The latter could be seen

# INTUSSUSCEPTION OF DUODENUM INTO OESOPHAGUS 393

as a thickened, narrow, cord-like structure extending towards the diaphragm, and was lost to view in the region of the oesophageal hiatus

Above the diaphragm the distal end of the oesophagus (O) was dilated for a distance of 5 cm. Its widest diameter measured 2.5 cm. Within it could be palpated

into the oesophagus for a distance of 5 cm beyond the level of the diaphragm, taking with it the pyloric antrum, the pylorus, and proximal portion of the duodenum. These formed a compact cone which had caused almost complete oesophageal obstruction (C). However, a probe could easily be passed alongside the right border



Fig 457—Showing O of Fig 456 with a vertical incision to expose the contents. C, Cone of lesser curvature, pylorus, and duodenum, O, Edges of incised oesophagus



Fig 458—The incision through the oesophagus has been extended into the anterior wall of the stomach to expose its interior. C, Cone of lesser curvature as before. P, Opening of pylorus, R, Mucosa of stomach

what eventually was shown to be the lesser curvature, pylorus, and proximal part of the duodenum (Fig 457). An incision opening the anterior wall of the stomach and extending to the upper limit of the oesophageal dilatation showed the following features (Fig 458). The contents of the stomach consisted of an homogeneous, cheese-like mass. The wall of the stomach was parchment-thin and all its rugosities had completely disappeared (R). The lesser curvature had invaginated

of this mass into the stomach. The opening of the pylorus was not visible until the longitudinal rugae of the lesser curvature within this mass were separated. The pylorus was therefore situated in the oesophagus (P). The apex of the transverse mesocolon, to which reference has already been made, was attached to the antero-superior surface of the proximal 2 cm of the duodenum. The upper part of the transverse mesocolon was contained within the oesophagus.

## A CASE OF BILATERAL PNEUMOTHORAX AND BILATERAL PENETRATING WOUNDS OF THE DIAPHRAGM WITH RECOVERY

By A J P GRAHAM

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PENETRATING wounds of the chest wall may result in injuries to abdominal organs, and the following is a description of a case in which bilateral injuries of the chest wall resulted in bilateral pneumothorax, penetration of both sides of the diaphragm with rupture of the spleen and liver, with complete recovery

### CASE REPORT

E B, aged 28 years, a corporal in the A T S, was admitted after a road accident. Sergeant B L was admitted at the same time with almost exactly similar injuries to the chest wall. As they had been travelling in the same lorry it appeared, therefore, that the mechanism of their production must have been similar. Another vehicle had collided with the side of the lorry in which they had been travelling. Both had been sitting against a wooden slat running along the inside of that side of the lorry struck by the other vehicle. The force of the impact had evidently caused the wood against which they were leaning to give way behind them, and the two broken ends of the slat had penetrated each side of the chest wall in both cases.

In the second woman splinters of wood were later removed from the tissues in front of both scapulae several inches away from the entry wounds in the mid-axillary regions.

On admission E B was in considerable pain, which was most severe in the lower thoracic region at the back. On immediate examination she was found to be suffering from shock with a rapid feeble pulse, pallor, and obvious dyspnoea. There was no evidence of severe blood-loss externally apart from blood-stained uniform and bandages.

Measures for the treatment of shock were employed, and half an hour after admission she had recovered sufficiently to allow further examination to take place. The blood-pressure was 125/85, pulse-rate 92, respirations 30 and shallow. There was no obvious cyanosis. The apex beat was displaced to the left, the exact distance not being measured. On removing the first-aid dressing two thoracic wounds were found. That on the left was a penetrating wound through the eighth and ninth intercostal spaces and eighth and ninth ribs in the anterior axillary line. Protruding from it were part of the omentum and some bowel. On the right an almost similar wound through the eighth and ninth spaces and ninth rib in the posterior axillary line was found. Through this air passed in and out with every respiration. This wound was promptly covered with a sterile dressing. There was no marked difference between the percussion note on the two sides, though on the right side air entry was faint. The abdomen was rigid, especially in the upper quadrants. No other serious injuries were found.

The patient's general condition improved rapidly, and an hour and a half after admission her blood-pressure was 150/100, pulse 100.

X-ray Examination revealed fractures of the ninth and tenth ribs behind the angles and in the posterior axillary line, and single fractures of the eleventh and twelfth ribs in the posterior axillary line on the right side of the chest. On the left there were fractures of the eighth and ninth ribs in the mid-axillary line. Examination of the lung fields showed a right pneumothorax with the heart shifted to the left, a partial pneumothorax and generally increased density of the lower half of the

lung on the left. The latter did not appear to correspond strictly to a lower-lobe collapse, part of the upper lobe being also involved.

Operation was decided on for the purpose of closing the chest wall and returning the omentum and bowel to the abdomen.

AT OPERATION—A transfusion was set up and two pints of Group O blood were given during and after operation. The prolapsed omentum was ligated and excised. The bowel, part of the transverse colon, was undamaged and was returned to the peritoneal cavity through the tear in the diaphragm. It was then seen that the left lower lobe was retracted two or three inches above the diaphragm, the space being occupied by air and communicating freely with the atmosphere through the chest wall, and with the peritoneal cavity. Protruding through the hole in the diaphragm was the upper pole of a ruptured spleen and a small accessory spleen the size of a grape. It was obvious that there was at least a partial pneumothorax on both sides. The condition of the patient was surprisingly good, and at no time did her respiration or heart give the anaesthetist much anxiety. A close-fitting mask with a Boyle's machine maintained a certain degree of positive pressure, giving gas, oxygen, and ether.

As it was necessary to excise the spleen, the original chest wound was continued downwards across the costal cartilages and then transversely across the abdomen. A considerable quantity of blood was found in the peritoneum, and bleeding was continuing from the splenic pedicle. Splenectomy was performed by Mr E W Sheaf. A rapid survey of other abdominal organs was made. No intestinal perforations were found, but palpation of the under surface of the diaphragm on the right revealed another tear through which the sharp ends of fractured ribs protruded. On examining the upper and posterolateral surfaces of the liver several lacerations were felt, the largest appearing to be about a quarter of an inch deep and one and a half inches long. These had been caused by the impaction of fractured ribs. It was considered unnecessary to suture the liver. After the abdominal incision was closed the tear in the left side of the diaphragm was sutured with catgut. Blood-clot was cleared from the left pleural cavity and the pleura and muscle layers resutured without drainage. Vaseline gauze and sulphaniilamide powder were applied and the skin wound left open at the site of the original chest-wall injury.

Attention was then directed to the wound on the right. The dressing was removed from the opening. Free entry and exit of air now occurred with every respiratory movement, but as far as could be ascertained there was no mediastinal flutter and no marked cardiac or respiratory embarrassment. A rapid wound excision with removal of sharp rib ends and loose bone fragments was carried out. The diaphragm and chest wall were closed without drainage as on the opposite side. According to d'Abreu routine closure of the chest without drainage is preferable to tube drainage provided post-operative collections of fluid in the pleural cavity are aspirated thoroughly. In this case it proved successful.

PROGRESS—Post-operatively continuous oxygen was administered through a B L B mask, and twelve hours later sulphathiazole in full doses and systemic penicillin, 50,000 units first dose and 30,000 units 3-hourly, were commenced. This dose of penicillin was maintained for



seven days, then half the dose was continued 3-hourly for a further two days. When the temperature had settled to normal for two days on completion of this course a total of 1,415,000 units had been administered. The highest recorded temperature was  $101.2^{\circ}$  twenty-four hours after operation. Two days after the injury the respirations were forty per minute, but by four days they had returned to normal.

Chest examination twelve hours after operation showed faint air entry on the right with a little fluid in the pleural cavity. On the left the air entry was much better, though breath-sounds were harsh in character and accompanied by a few rales. Coughing was encouraged by the use of potassium iodide, with small doses of morphine to depress pain sensation but not the cough reflex. This appeared to be quite successful, as sputum was easily cleared. Deep breathing exercises with carbon dioxide and oxygen for five minutes hourly were begun on the first day and lung expansion exercises performed twice daily with a masseuse.

Four days after operation the heart was still displaced to the left, though less than formerly. There was

generally increased density of the left lower lobe. On the right there was no fluid and air absorption was complete except in the apical region. Respirations were normal at rest, but dyspnoea was evident on exertion. This gradually passed off as the lungs expanded.

Recovery was uneventful. A chest radiograph five weeks after operation showed no abnormality except for non-union of the eleventh rib. This caused a slight clicking, but no pain.

**Discussion**—A case of bilateral abdomino-thoracic injury is described. It is of unusual interest in that one complete lung and part of the other were collapsed. In spite of this, the vital capacity was not reduced beyond that compatible with life and with treatment the patient made a complete recovery.

My thanks are due to Mr E W Sheaf for permission to publish this case and for his advice throughout.

## A CASE OF FILARIAL FUNICULITIS

BY SURGEON LIEUTENANT COMMANDER H R I WOLFE, R N V R  
AND SURGEON LIEUTENANT COMMANDER A L SCHOFIELD, R N V R

IN these days of global warfare and consequent movements of Service personnel, tropical diseases and their sequelæ are much less confined to the tropics. The following case of filarial funiculitis, occurring nine months after the patient's return from Africa, provides an example of the importance of being alive to the possibility that the symptoms complained of may be a manifestation of a previous symptomless tropical infestation.

### CASE REPORT

**HISTORY**—The patient, G A, a Naval Air Gunner, aged 25. At 17.30 hr on Feb 9, 1945, he felt a stab of pain in the left groin while climbing down from an aircraft to the flight deck. He attributed this to the pressure of his parachute harness. Later there was slight pain and swelling of the left scrotum, but he slept well. Next morning, on rising, the pain and swelling were still present and became worse as he went about his duties. He reported at the Sick Bay.

**Previous History**—Measles aged 6, diphtheria aged 10, and in 1939 pneumonia. In March, 1942, he was drafted to West Africa, where he spent four weeks in the jungle. In June, 1942, he was transferred to East Africa, being stationed in a game reserve, where he remained until April, 1944. In June, 1943, a small right hydrocele, which had been present for five years, suddenly increased in size. A radical cure was performed, with an uneventful convalescence, and there has been no recurrence. On his way home in May, 1944, he developed his first attack of malaria when three days out from Mombassa. Apart from this illness and the operation for hydrocele, he was perfectly fit during the whole commission.

**ON ADMISSION**—At 20.15 hr on Feb 10, when his ship returned to her base, he was discharged to this hospital as a case of suspected strangulated inguinal hernia. He was lying comfortably in bed without rise in either temperature or pulse-rate ( $T 97.6^{\circ}$ ,  $P 76$ ). The scrotal skin on the left side was indurated and oedematous, but the left testicle and epididymis, surrounded

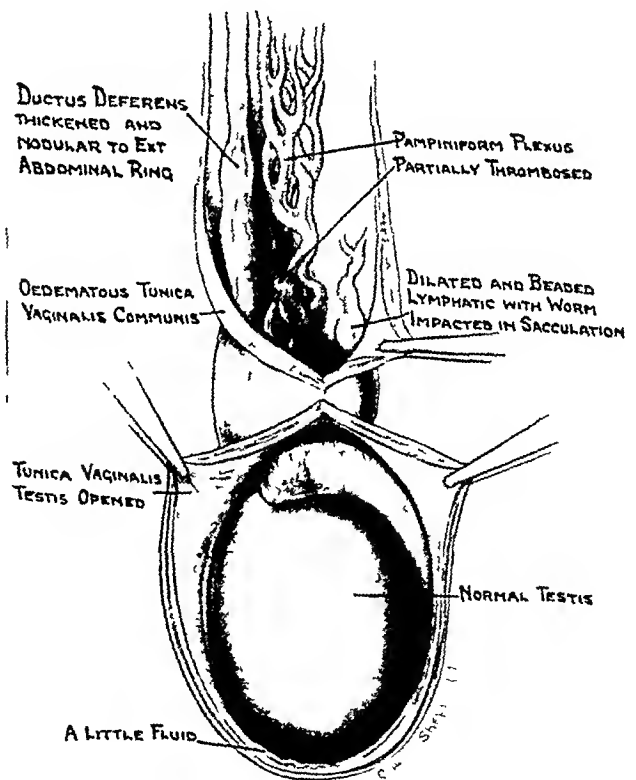


FIG 459—Drawing of findings on exploring cord and testicle

by a small lax hydrocele, felt normal. Extending from just above the left globus major to the external abdominal ring, there was a fusiform, tender thickening of the cord. This was less marked in the inguinal canal.

Tenderness was elicited in the left iliac fossa and hypogastrium. Apart from slight thirst, no other abnormal signs or symptoms were noticed. No rigor, headache, malaise, anorexia, nausea, or vomiting. The bowels were regular and micturition was normal. Examination of the rectum, chest, and cardiovascular system revealed no other abnormal physical signs.

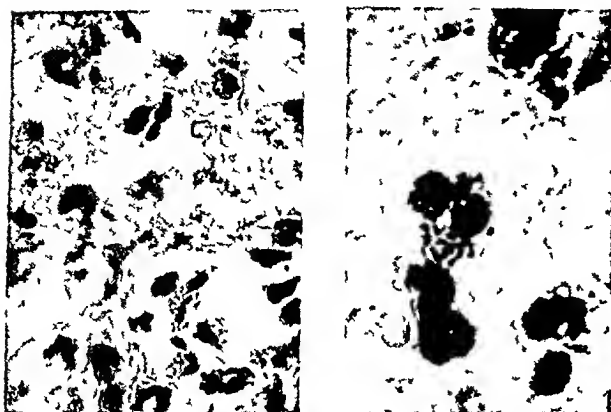


Fig 460—Microphotographs of sections of nodules taken from surface of vas deferens. A,  $\times 600$ , B,  $\times 1500$ .

#### Blood-count —

R B C	5,000,000
Hb	98 per cent
C I	I
W B C	7,400
Polymorphs	62 per cent
Lymphocytes	23 " "
Monocytes	9 " "
Eosinophils	4 " "
Basophils	2 " "

#### Urine — Nothing abnormal detected

Following rest in bed, the scrotal swelling subsided almost completely, but the tender mass above the testicle remained. On getting up, the swelling quickly recurred.

On a pre-operative diagnosis of torsion of a testicular hydatid, or an acute funiculitis of unknown aetiology, operation was advised.

**AT OPERATION**—The cord and testicle were explored through a left inguinal incision (Fig 459). The cord from the internal to the external abdominal ring was thickened and oedematous, and a watery exudate was visible beneath its coverings. Between the external abdominal ring and the globus major of the epididymis the cord had expanded into a firm fusiform mass about the size of a walnut. The tunica vaginalis was incised and found to contain a little clear watery fluid. The testis and epididymis appeared normal. The coverings of the cord were incised from the internal ring to the upper pole of the testis. The former were about  $\frac{3}{8}$  in. in thickness below the external abdominal ring and much less so in the inguinal canal. Between the upper pole of the testis and the external abdominal ring the vas deferens was inflamed and nodular. On its surface was a number of discrete yellowish nodules varying in size from 0.5 mm to 3.0 mm in diameter. Some of these were sent for microscopy (Fig 460). The pampiniform plexus was engorged and some of the radicles in contact with the inflamed vas were thrombosed. On dissection, an enormously dilated and varicose lymphatic was found running in the posterior coverings of the cord down to the upper pole of the testis. Through its thin wall the wriggling, white, hair-like coils of a worm were seen. The lymphatic, with the worm inside, was

excised and the specimen sent for examination (Fig 461). A blood-smear was taken and the wound then closed in layers.

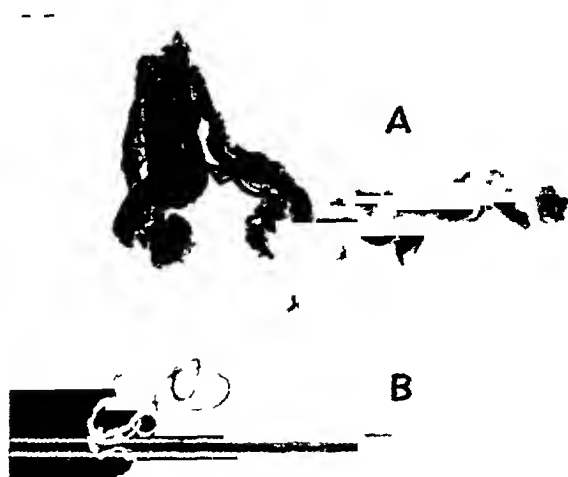


Fig 461—A, Lymphatic on oo catgut, B, Worm on finely drawn capillary tubing ( $\times 3$ ).

**PROGRESS**—Convalescence was uneventful, with healing by first intention. The scrotal oedema subsided in a week, and the funiculus had almost completely resolved on his discharge from hospital three weeks later. Two months after operation there were no abnormal signs or symptoms.

**PATHOLOGICAL REPORTS**—Daily blood examinations at 22.30 hr for three weeks, and that of the specimen taken during the operation, failed to show microfilaria. Further diurnal blood examinations at 22.30 hr and 10.30 hr for a period of a week, one month later, were also negative.

The worms were identified as *Filaria bancrofti* by Lieutenant-Colonel W F Harvey, I M S (Ret).

The nodules taken from the surface of the vas deferens were found to consist of lymphoid follicles, packed with eosinophils, and with marked lymphangiectasis (Fig 460).

#### COMMENT

Though cases of filarial funiculitis must be rather unusual in this country, Lt-Colonel Grieg states that it is reported to be very prevalent among personnel serving in the Pacific theatre of operations (Fogel and Huntington, 1944). With the return of Service men from Africa and the Pacific it is not unlikely that further cases will be seen, and therefore when a case of funiculitis of obscure aetiology is encountered, the possibility of filarial infestation should be borne in mind.

We wish to thank Surgeon Captain H F Briggs, R N, for permission to publish this case. We express our thanks to Lt-Col W F Harvey, C I E, I M S (Ret) and Lt-Col E D W Grieg, C I E, I M S (Ret) for their help and advice, to Mr Pettigrew for the photographs, and to Mr Clifford E Shipley for the drawing.

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## BAYONET WOUND OF THE TRANSVERSE COLON

BY SURGEON COMMANDER A LONG, R N

## CASE REPORT

A cadet, aged 18 years, while undergoing training at a Pre-OCTU Centre, jumped from a height of nine feet on to the fixed bayonet of the man immediately in front. This entered his abdomen and there was some brisk hæmorrhage from the wound. On being seen soon afterwards by a Medical Officer, he was found to be moderately shocked and two pints of reconstituted serum were given. He was admitted to R N Sick Quarters one hour afterwards.

ON ADMISSION—Temperature, 97°, pulse, 88, blood-pressure, 108 mm systolic, pallid and rather shocked. Abdomen—small incised wound of entry of bayonet just external to the right rectus muscle on a line between the anterior superior spine and the umbilicus and the wound of exit of the point below twelfth rib 2 in from midline in the costovertebral angle. Some brisk hæmorrhage from wound. Generalized tenderness and rigidity. An intravenous drip of glucose and saline was commenced and two pints of serum given in the course of the next hour.

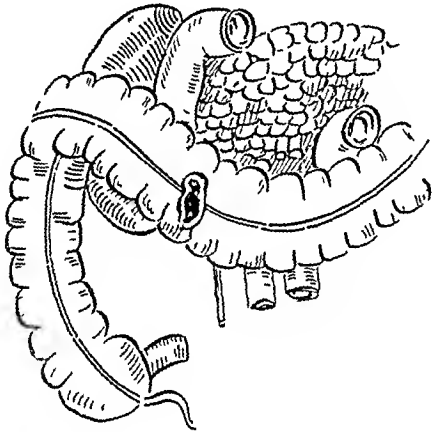


FIG 462—Drawing showing perforating wound of transverse colon

AT OPERATION (one hour later)—Under nitrous-oxide, oxygen, and ether anæsthesia, the abdomen was opened in the midline at the level of the umbilicus. Faecal smell and gas were present on opening the peritoneum. Small amount of blood-clot evacuated from

the right iliac fossa. Two gaping wounds of the transverse colon were found in the region of the hepatic flexure. These were immediately firmly sutured. Small intestine and other viscera were examined and found intact. During this time blood was seen entering the peritoneal cavity from the wound in the right iliac fossa, and on exploration it was found that the deep epigastric artery was severed. Hæmostasis was secured and a large drainage tube inserted through this wound after excision of skin edges, 5 g sulphonamide powder was sprinkled over the suture line of the colon. Wound of exit treated similarly. Closure.

PROGRESS—Immediately following operation the patient was placed in a high Fowler's position. One gramme soluble M & B 693 was given into the intravenous drip and repeated at three-hourly intervals until consciousness was regained, then 1 g was given four-hourly until a total of 31 g had been given. The glucose-saline drip was kept in situ for five days, giving approximately four to five pints in twenty-four hours, and fluids were restricted by mouth. For the first three days he complained of severe colicky pains in the abdomen and morphine was exhibited freely. The tube drained well and was removed on the fourth day. Some slight elevation of temperature occurred during the first three days, afterwards becoming apyrexial, he vomited on one occasion only. Bowels were opened normally on the fifth day and afterwards convalescence was uneventful. Sutures were removed on the ninth day. All wounds healed well, slight hyperæsthesia was present over the front of the right thigh (L 2 and L 3). The patient was free from symptoms and was discharged to convalescence soon afterwards.

## Summary—

1 Penetrating wound of abdomen, a bayonet passing completely through the peritoneal cavity and emerging below the right twelfth rib, inflicting damage only to the transverse colon.

2 Immediate operation and wounds of colon sutured.

3 Free drainage, high Fowler's position, restriction of fluids by mouth, and continuous intravenous drip of saline and glucose for five days following operation.

4 Chemotherapy 31 g of M & B 693 given in five days.

5 Uneventful recovery.

## A CASE OF MULTIPLE DUCT PAPILLOMA OF THE MALE BREAST

BY JAMES MORONEY

VISITING ASSISTANT SURGEON, BROADGREEN HOSPITAL, LIVERPOOL

THE occurrence of a duct papilloma in the male breast is most unusual.

## CASE REPORT

HISTORY—A man, aged 31, was admitted to hospital complaining of an intermittent blood-stained discharge from the right nipple for two years and the presence of a swelling for two months. His father had had an operation on his breast many years ago.

ON EXAMINATION—Beneath the areola were two well-defined nodular swellings. They were bluish in

colour and gentle pressure caused bright-red blood to flow from the nipple.

The left breast and the axillæ were normal. There were no cutaneous papillomata elsewhere.

AT OPERATION (January, 1944)—The nipple, areola, and surrounding skin containing the nodules were excised.

Convalescence was uneventful.

MICROSCOPICAL PATHOLOGICAL EXAMINATION (Dr C V Harrison)—Section shows extensive intraduct papilloma of the breast (Fig 463).



A



B

FIG 463—Microphotographs showing extensive intraduct papilloma A, 15 B,  $\times 97.5$

### COMMENTARY

Duct papilloma is not a common condition, even in the female. Wakeley (1945) has reported a series of 52 cases, but all were in females. I am unable to trace a case of duct papilloma in the male.

The family history of male breast disease is interesting. The age of the patient falls within the commonest age incidence in the female.

Treatment by simple excision is adequate.

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## A CASE OF CARCINOMA COLI IN A CHILD

By F. D. SANER

In the case here reported the previous history, radiographic appearance, and operative findings were typical of an annular stenosing growth of the colon. The unusual feature, of course, is the age, and I am unable to find any detailed record of a similar case.

In Dargeon's book *Cancer in Childhood*, Ewing, referring to the distribution of 183 primary malignant tumours in childhood, mentions 2 as occurring in the rectum and 1 in the stomach, in a further group of 424 childhood cases (Piest) 7 are classified under "Intestine" without any particulars. Both these groups of cases were published some sixty or more years ago. More recently 750 cases of tumours occurring in children under 15 were tabulated at the Mayo Clinic and another group of 215 (infancy to 15 years) at the Memorial Hospital in New York, no mention is made of colonic growths in either of these groups.

I do not wish to convey the impression that a confident diagnosis was made previous to the operation, it was not, but at the same time no satisfactory alternative diagnosis was suggested.

### CASE REPORT

**HISTORY**—Elizabeth G., aged 11 yr 1 mth. According to the parents, the child (weight 8 lb at birth), though always rather tall for her age and thin, had been a healthy child and apart from what are generally referred to as childish complaints, e.g., chicken-pox, etc., had been

exceptionally free from minor ailments affecting the gastro-intestinal tract or elsewhere. Nor, so far as the parents knew, was there any history of cancer in either of their own families.

In the middle of May, 1945, the girl had a sharp attack of diarrhoea and vomiting lasting some 24–36 hours, but since the mother had a similar attack at the same time it was attributed to some food irritant. On the last day in May there was a recurrence of abdominal pain and nausea—this time the mother was not affected—which persisted for some 3 or 4 days, when medical advice was sought. At this time it was stated that the bowel was acting, no vomiting was reported, nor did the child appear at all ill. On examination, however, the abdomen was thought to feel "full", though no other signs were detected. The condition remained much the same for a week, after which a definite improvement occurred and was maintained for about a further two weeks, but again the pain returned, was more severe, and was accompanied this time by vomiting and complete arrest of bowel action, when seen some 24 hours later abdominal distension was obvious.

**ON ADMISSION**—Shortly after admission a sedative was given, followed some 3 hours later by a glycerin enema which resulted in an action of the bowel, and from then on a steady improvement was maintained without further recurrence of symptoms, and the distension subsided. A week later an X-ray examination (barium meal follow-through) was made which showed the barium to be arrested at a point in the proximal half of the transverse colon, a few days later a barium enema confirmed the findings of the meal (Figs 464, 465).



FIG 464—Radiograph following barium meal, showing barium arrested in proximal half of transverse colon



FIG 465—Radiograph following barium enema, and taken 14 days after Fig 464, confirming the site of obstruction

The upper half of the abdominal wall was at all times kept taut so that no mass was found either on ordinary or at the radiological examination, when the child was anaesthetized it was thought that a small mass could be felt a little above and to the right of the umbilicus, though even then there was considerable doubt

AT OPERATION—A laparotomy was performed on July 13 when, at the site shown in the radiographs, a typical annular carcinoma of the transverse colon was found (Fig 466) with obvious involvement of several mesenteric glands close to the bowel wall. No other abnormality was seen. After resection of a length of colon and mesentery the divided ends of the gut were closed and a lateral anastomosis between the proximal and distal segments of the transverse colon was performed.

Recovery from the operation was smooth and uneventful.

THE SPECIMEN—Dr P O Ellison kindly examined the specimen and has reported as follows: "Segment of transverse colon. The proximal end is ballooned and the distal end contracted, the centre portion is occupied by a neoplasm which completely encircles the bowel, the degree of stenosis is considerable and the lumen of the gut is reduced to a narrow chink. The growth itself, some  $\frac{1}{2}$  in thick, is very firm to touch, with edges everted and surface ulcerated. In the adjacent subperitoneal tissue there are about a dozen scattered nodules varying from 2–3 mm up to 10 mm in diameter."

"Microscopical examination reveals a neoplastic process involving the whole bowel wall from mucous membrane to subperitoneal tissue, with the main mass of growth between the muscularis mucosa and muscular coat, there is a considerable degree of fibrosis in this region and the general appearance is not unlike a carcinoma of the stomach."



FIG 466—Photograph of portion of colon resected, showing the annular carcinoma

"The cells are columnar in type, tending to form acini with low columnar and cubical cells which in some

instances are flattened, in general, the cells are solitary or in small groups of the mucus-producing type, and many of them present a signet-ring appearance, in the inner muscular layer there are areas of frank colloidal degeneration. Unlike the usual type of columnar-celled carcinoma, the mucous membrane is not replaced by neoplastic cells, in fact, it is intact and packed with normal mucous glands, though with some indication

that the process may have originated in the deepest of these glands.

"Most of the subperitoneal nodules consist of secondary deposits with closely packed acini composed of cells distended with mucus and flattened nuclei producing the signet-ring appearance."

"*Diagnosis* Stenosing mucoid carcinoma of large intestine."

## TRAUMATIC ANEURYSM OF THE COMMON CAROTID ARTERY ASSOCIATED WITH MASSIVE INFARCTION OF THE BRAIN

BY NORMAN WHALLEY

NEURO-SURGICAL UNIT, NEWCASTLE GENERAL HOSPITAL

PENETRATING injuries to the neck are always potentially serious problems. On account of their intimate relationships and complete lack of protection, the great vessels, the ninth, tenth, eleventh, and twelfth cranial nerves, the nervous plexuses, and the viscera are all extremely vulnerable to trauma.

Makins (1922), in an analysis of 128 cases of injury to the carotid vessels in the War of 1914-1918, noted that in most cases the wounds of the soft parts were minor in character. He pointed out that no large open wounds of the soft parts were seen in the cases studied and that during a period of three years' duty as Consulting Surgeon he saw no patient in whom the common carotid artery had been tied for control of primary hæmorrhage. The inference is that many carotid injuries die within a short space of time from primary hæmorrhage, and that it is the apparently minor neck injuries which are seen in hospital. In 86 of his 128 cases some form of hæmatoma or traumatic aneurysm developed—a percentage of 67.1. He drew attention to the difficulty caused in diagnosis when cerebral symptoms following an injury to the carotid vessels are complicated by skull fractures, and also drew attention to the fact that injuries to the brachial plexus may cause diagnostic difficulty when occurring in association with cerebral complications.

The case reported below is considered worthy of record as it illustrates the diagnostic difficulties which can occur when cerebral symptoms and neurological signs are found in patients who have suffered both a head injury and a penetrating neck injury.

### CASE REPORT

W. T., a German prisoner of war, was wounded in the neck in Normandy on July 8, 1944. When first examined in England on July 9, his records show that he was conscious and co-operative. He had a gunshot wound of entry on the right side of his neck and a gunshot wound of exit on the left side of his neck. The notes stated that there was paralysis of the left arm and hand. Both legs were moving freely on this date. He also had a superficial wound over the right shoulder. There was no further information given. On July 12 he was evacuated to the Newcastle General Hospital under the care of Mr. G. F. Rowbotham. On admission he was drowsy and complained of severe headache.

The following points were noted—

- 1 Bruising of the right temporal region of the scalp.
- 2 Gunshot wound of entry in the right side of the neck overlying the sternomastoid muscle—just below

the inferior border of the thyroid cartilage. There was a great deal of bruising and extravasation into the soft tissues.

- 3 Gunshot wound of exit in the left side of the neck 1 in. above the clavicle near the posterior border of the left sternomastoid muscle.



1 2 3 4 5 6  
CENTIMETRES

FIG. 467.—Illustrating (a) Traumatic aneurysm of common carotid with thrombosis of the vessels, and (b) Infarction of cerebrum and compression of lateral ventricle.

- 4 Small superficial gunshot wound over the point of the right shoulder.

5 He had a complete hemiplegia on the left side, with absence of the deep tendon reflexes.

6 There were no abnormal neurological signs to indicate injury to any of the cranial nerves.

7 There was no clinical evidence of injury to the sympathetic trunks on either side of the neck.

- 8 There was no papilloedema.



9 There was diffuse pulsation in the lower part of the neck, and the superficial temporal pulse on the right side was absent.

Radiographs of the skull, neck, chest, and right shoulder showed no evidence of fracture nor the presence of any radio-opaque foreign body.

The diagnosis made by Mr G F Rowbotham was that of traumatic aneurysm of the right common carotid artery, but in view of the bruising in the right temporal region it was considered advisable to explore the extradural and subdural spaces to exclude, in particular, a subdural hæmatoma. Three days previously the right paralysis could well appear to have been due to a brachial plexus injury, particularly in view of the site of the exit wound and the otherwise perfect condition of the patient.

AT OPERATION.—Under local anæsthesia two burr holes were made—one in the right temporal region and the other in the right parietal region. There was no extradural bleeding. The dura mater was tense and pale in colour. On opening the dura mater at both burr holes there was no subdural collection. The brain was very tight and œdematous and tended to protrude through the dural openings.

This minor exploration confirmed the diagnosis and the patient's condition gradually deteriorated and he died on July 14.

POST-MORTEM EXAMINATION.—The missile had penetrated the right sternomastoid muscle and had then caused a large hæmatoma in and around the right carotid sheath. The upper pole of the thyroid gland had been penetrated. The missile had passed behind the œsophagus in a downward direction and to the left, emerging in the left side in front of the scalenus anticus muscle, and had then passed through the posterior part of the left sternomastoid muscle about 1 in above the clavicle. The brain, the right carotid sheath and contents, the common carotid artery, internal carotid artery, external carotid artery, and left brachial plexus (which appeared uninjured) were dissected out and forwarded to Professor A F Bernard Shaw, who made a detailed pathological examination and reported as follows—

*Right Carotid Sheath*.—This is 8.0 cm long and the site of diffuse hæmorrhage on its anterior and external surfaces. The common carotid artery from its lower end upwards for 3.0 cm is intact and the lumen empty, at this level on its anterior surface, is an aneurysm 0.5 cm in diameter (Fig 467). A greyish-pink thrombus which fills the sac extends into the remainder of the common carotid and passes upwards to fill the external and internal carotids, each of which is 2.0 cm long.

Histologically the aneurysm is of traumatic origin, as the wall of the artery has been torn open for a length of 0.8 cm, the gap being filled with thrombus which continues into the carotid sheath, the latter forms the wall of the sac and none of the components of the arterial wall enter into its composition. No foreign body was found in the microscopic structure of the thrombus in the three arteries indicates that it has been initiated in the aneurysm and rapidly grown by propagation into the carotids.

The internal jugular vein is empty, its intima is intact, but at the level of the aneurysm there is subintimal hæmorrhage over a length of 2.0 cm on the side next to the common carotid.

*Left Common, Internal, and External Carotids*.—These measure 9.0 cm. The carotid sheath and internal jugular vein are missing. There is slight diffuse hæmorrhage in the adventitia of the carotid vessels, but no other abnormality.

*Larynx, Œsophagus, and Thyroid*.—Extensive hæmorrhage is present in the fascial plane posterior to the œsophagus and extending over the surface of the right lobe of the thyroid, which is the site of laceration at the upper pole. The œsophagus is intact and there is

no hæmorrhage in the tissues between it and the larynx. There is submucosal hæmorrhage in right pyriform fossa, but no trauma. At the posterior commissure of the vocal cords are two small decubitus ulcers.

*Left Brachial Plexus*.—Shows no trauma or hæmorrhage, but special stains reveal some nerve-fibres with swelling and disintegration of the myelin sheaths.

*Brain*.—The right internal carotid is filled with thrombus which extends into the right middle and anterior cerebral arteries, occluding the lumina. There is early infarction—confirmed histologically—of the whole of the right cerebral hemisphere, producing intense œdema with compression of the lateral ventricle (Fig 467).

*Comment*.—The series of events appears to be as follows. Traumatic aneurysm of right common carotid, hæmorrhage into the tissues of the neck, thrombosis in the aneurysm with propagation into the right common, external, and internal carotids, right middle and anterior cerebrals, followed by infarction of the right cerebral hemisphere.

The projectile responsible for the trauma was probably of small dimensions, as indicated by the small size of the tears in the common carotid and upper pole of the thyroid gland.

## SUMMARY AND DISCUSSION

This patient received a penetrating injury to his neck on July 8, 1944, and when seen on July 9 had a paralysis of the left arm and hand. There are no further clinical records available, but as he was considered fit for evacuation on that date no undue anxiety could have been felt for him. By July 12 he was drowsy, suffered severe headache, and had developed a complete left-sided hemiplegia. Because of the associated head injury it was considered wise to explore the right side of his head to exclude any intracranial hæmorrhage. This negative exploration confirmed the original clinical impression. It would seem that the initial monoplegia was due to an embolus which, originating at the site of injury to the right common carotid artery, lodged in a branch of the middle cerebral artery. Later, progressive thrombosis of the common carotid artery led to complete obstruction and spreading thrombosis in an upward direction, blocking the external and internal carotid arteries, and then, by further extension, the middle and anterior cerebral arteries. The accompanying photograph of the cut brain illustrates extremely well the intense œdema and swelling of the right cerebral hemisphere, secondary to thrombosis of the right middle and anterior cerebral arteries. This thrombosis is a spreading one from the common carotid artery and originates in a traumatic aneurysm. The photograph also shows the post-mortem specimen of the common carotid artery and its two branches with the traumatic aneurysm in situ.

I wish to express my gratitude to Mr G F Rowbotham, Neuro-surgeon, Newcastle-upon-Tyne General Hospital, for his permission to publish this case and for his help and advice. I also desire to thank Professor A F Bernard Shaw, of the University of Durham, for the detailed pathological report, the photograph, and for the interest he has shown in this case.

## REFERENCE

- MAKINS, G H (1922), *Official History of the War, Medical Services, Surgery of the War*, 2, 223.

## REVIEWS AND NOTICES OF BOOKS

**Illustrations of Regional Anatomy** By E B JAMIESON, M D Sixth edition In one bound volume Pp xii + 320 1946 Edinburgh E & S Livingstone Ltd 75s

JAMIESON's *Illustrations* are well known the world over, and now that the seven separate sections have been published in one bound volume surgeons and anatomists alike will benefit in that they have a book of reference. This new sixth edition contains a few new illustrations and an index has been added, which is a real help as any particular structure may appear in several plates. An excellent volume which will always be popular.

**Atlas of Surgical Approaches to Bones and Joints** By TOUFICK NICOLA, M D, F A C S, Professor of Orthopedics, New York Polyclinic Medical School and Hospital Pp 218 1945 New York The MacMillan Co \$5 00

THIS Atlas contains a variety of clear diagrams showing the surgical approach to bones and joints. Major-General Kirk, the Surgeon-General of the United States Army, has written a Foreword in which he states that approximately 70 per cent of war casualties requiring surgical care are primarily extremity injuries. Therefore this book has come at an opportune time, because it reveals to surgeons, both at home and abroad, the surgical approaches to the skeleton.

The book makes clever use of lucid illustrations in conjunction with concise enumeration of each step of action.

To the practising surgeon this pictorial atlas will be invaluable as a quick reference to his current problem. The illustration are clear and the amount of text is reduced to the minimum. The author quite rightly estimates that each illustration is worth 10,000 words of text.

**A Textbook of Surgery** By JOHN HOMANS, M D, Clinical Professor of Surgery, Emeritus. Compiled from Lectures and Other Writings of Members of the Surgical Department of the Harvard Medical School. Sixth edition 9½ x 6½ in Pp 1278 + viii, with 530 illustrations 1945 Springfield, Ill Charles C Thomas (London Baillière, Tindall & Cox) \$8 00

THE first edition of this well-known text-book appeared in 1931 and since that date six new editions have been forthcoming, this in itself indicates in no small way the popularity the book enjoys. The new sixth edition shows signs of careful revision and can be said to be right up to date. The use of the sulpha drugs and penicillin in surgery has been given its rightful place. The numerous illustrations are for the most part pen-and-ink drawings, and they have been carefully selected to bring out important points in the text. These illustrations are very refreshing and somewhat novel compared with the usual run of pictures in text-books. We feel sure that this pictorial method of gaining knowledge is of real value to the reader, be he undergraduate or post-graduate.

The chapter dealing with fractures is most comprehensive and practical, and the reader obtains a first-class knowledge of this important branch of surgery. The influence of the second world war has caused some alteration in the treatment of fractures, but on the whole this is very little. All the special branches of surgery are incorporated in this one volume, and Professor Homans has had the good fortune to obtain the services

of his surgical colleagues in writing some of the special chapters.

A bibliographical index is incorporated at the end of the book, this is quite a unique feature in a text-book of surgery, but it does serve a useful purpose.

A comprehensive subject index completes the volume. This text-book will still remain popular as it gives the student just what he requires to know for his final examination in surgery.

**Plaster of Paris Technique in the Treatment of Fractures and Other Injuries** By Lt-Col T B Quigley, M C, M D 9½ x 6 in Pp 107 + xiv, with 103 illustrations 1945 New York The Macmillan Company 18s net

THIS volume devoted to the plaster-of-Paris technique is an excellent contribution on the application of this principle. Simplicity is claimed as its keynote, but to this might well be added clearness, for the author by his text and illustrations has made it easy for the reader to understand exactly how and why each step is taken in the application of plaster casts.

The application of plaster to injured limbs in the hands of the expert is simple, and it is therefore satisfactory in this volume to read of the dangers which may be encountered. His advice "when in doubt, pad a limb before the application of a plaster cast", is excellent. The unpadded plaster, whilst useful and safe over a limited field, is a source of danger in the hands of a novice. The warning of danger which the symptom of pain gives, is above all of importance, and here it is rightly drawn attention to.

**Extensile Exposure applied to Limb Surgery** By ARNOLD K HENRY, M B (Dubl), M Ch (Hon, Cairo), F R C S I, Emeritus Professor of Clinical Surgery in the University of Egypt 9½ x 6½ Pp 180 + viii, with 127 illustrations 1945 Edinburgh E & S Livingstone 30s net

THIS book is so much more than a guide to exposure of the long bones that one feels inclined to criticize its title, though it would be difficult to improve upon the author's choice of the term "extensile" to indicate an exposure which, like the tongue of the chameleon, can be made "to reach where it requires". Everyone who has had experience of the surgery of peripheral nerves and blood-vessels knows how often he feels the need for more room, and therefore many besides orthopaedic specialists will appreciate the sound practical advice with which this book abounds. Exposure may be extensile not only in length, but in depth and even in conception, amounting almost to the combination of two operations in one. A good example is the exposure of the main neurovascular bundle of the arm through the posterior incision for the musculospiral nerve and humeral shaft. We would suggest that the next edition should show how to display the whole course of the deep femoral in addition to the superficial femoral artery, a problem which taxes the ingenuity of the surgeon who has to hunt for an arteriovenous fistula in the thigh.

But the prime virtue of the book is the stress it lays upon anatomy of the living body in planning the approach to the deepest parts of a limb so that only the minimum of damage may be done to any of its tissues. To do this efficiently the surgeon must be able not only to see but also to feel his way into tissue planes, and Professor Henry is in the good company of the great anatomist-surgeons of the past in advocating the judicious use of

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the fingers gently to feel, grasp, or retract muscle bellies or neurovascular bundles. Even taking into consideration all the advantages of the no-touch technique, it must be acknowledged that an instrument can rarely be as gentle and can never be as sensitive as the finger, and with proper precautions the fingers may be used with safety.

The excellence of the illustrations, which must be the product of much study of operations, dissections, and pictures, is beyond all praise, and the whole is flavoured by the author's happy knack of making the English language as extensible as his exposures. It would be well if this book were to be studied by teachers of anatomy as well as by surgeons, since Henry's enthusiasm might even lead to a revival of interest in topographical anatomy which is now so much despised and is therefore so neglected.

**Le Catgut** Les Ligatures et les Sutures chirurgicales a travers les Ages By Dr A FANDRE With a Preface by Professor LOUIS BRUNTZ, Nancy 9½ x 6½ in Pp 651 + viii, with 137 illustrations 1944 Paris Masson et Cie No price stated

Who would have thought that the subject of Catgut 'served a book of 651 pages? Yet this work is interesting and a mine of information, at once historical, scientific, and technical. The first part deals with the history of the use of ligatures for hæmostasis and the second part makes a detailed scientific and technical study of catgut, and the third portion deals with the various laws in different countries affecting the preparation of catgut. There is a lengthy bibliography. This is a good book to keep for reference in a medical library.

**A Textbook of Surgery** By American authors Edited by FREDERICK CHRISTOPHER, BS, MD, FACS, Associate Professor of Surgery, Northwestern University Medical School, Chief Surgeon, Evanston (Illinois) Hospital. Fourth edition, revised and reset 9½ x 6½ in Pp 1548 + xxvi, with 1483 illustrations on 764 figures 1945 London and Philadelphia W B Saunders Co, Ltd 50s net

THE fourth edition of this well-known American textbook of surgery has been completely revised and largely reset. Several new sections have appeared dealing with military surgery, chemotherapy in surgical conditions, and the use of penicillin in surgery. In a large comprehensive text-book of surgery written by over two hundred contributors it is pleasing to find that the whole range of surgery has been adequately covered. Of necessity some sections are better than others, but Professor Christopher is to be congratulated on the able way he has made use of his contributors so that nothing of importance is missing. The outstanding sections of the book are by Adson, dealing with sciatica and cervical rib, Donald Balfour, writing on tumours of the stomach, and Elliott Cutler on gastric ulceration. These are masterful and fascinating to read and are illustrated with original drawings. There are nearly fifteen hundred illustrations in the book, and on the whole they are of a high order of merit and do enhance the value of the volume. Quite a novel feature of the book is a complete list of references at the end of each section, thus thoughtful inclusion will prove of real help to many surgeons who want to look up any particular condition more fully. The references are almost entirely American, but this is only to be expected in a text-book written by American authors.

British surgeons will find this volume of value as a book of reference.

**An Introduction to Clinical Surgery** Surgical Wherefores and Therefore A Reasoned Explanation of Surgical Note-taking By CHARLES F M SAINT, CBE, MD, MS, FRC S (Eng), FRC S, Professor of Surgery, University of Cape Town 8½ x 5½ in Pp 293 + vii 1945 Cape Town Published for the Post-Graduate Press by The African Bookman 25s

THE appearance of this book is well-timed, for it is essentially clinical in its outlook and is a reasoned explanation for careful surgical case taking. The student of to-day is so often embarrassed by the magnitude of the curriculum that clinical subjects are inclined to be rushed and note taking is scanty or non-existent. There is also a tendency to-day for diagnosis to be made on various tests, X rays, or blood-counts, to the exclusion of a careful case history and clinical examination. It is therefore refreshing to read Professor Saint's *Surgical Wherefores and Therefore*, his mellowed clinical experience has been utilized to the full in this book.

Both the under-graduate and post-graduate will benefit by reading this book, as it contains a vast amount of clinical observations that are not to be found in the average modern text-book. Adequate treatment cannot be given to any surgical condition unless the diagnosis is correct, and the practitioner will find this book a valuable guide to the diagnostic problems of surgery. A most useful book and one that surgeons will enjoy reading.

**Radiological Examination of the Small Intestine** By ROSS GOLDEN, MD, Professor of Radiology, College of Physicians and Surgeons, Columbia University, Director of the Radiological Service, The Presbyterian Hospital, New York 10 x 7 in Pp 239 + xiv, with 75 illustrations 1945 London J B Lippincott Co 36s net

WITH the increasing use of X rays in abdominal conditions new facts are forthcoming at an ever-increasing rate. The extended use of the Miller-Abbott tube is proving of value not only to the surgeon but also to the radiologist, for its use enables him to portray more exact films showing definite abnormal conditions. This monograph is the work of many years' careful study, and the author has presented the profession with a useful book of reference in which such conditions as regional enteritis, inflammatory lesions, tuberculous lesions, and neoplasms are beautifully portrayed in X-ray films. It is pleasing for the reader to be able to see not only the X-ray picture, but also the actual pathological lesion after removal from the patient. An excellent bibliography is to be found at the end of the book.

**El Codo Sus Fracturas y Luxaciones** By D ANTONIO H-ROS CODORNIU, Madrid 9½ x 6½ in Pp 260 + xvi, with 149 illustrations 1945 Madrid Cirugia del Aparato Locomotor Price not stated

THIS is the second volume of a series of monographs on orthopaedics and traumatology. It is perhaps a little prolix, but for the author a labour of love. He covers the ground from comparative anatomy of the joint to a list of salty proverbs relating to its function, such as one would expect Spain to produce. The mechanics of the complicated movements over the various curvatures of the joint surfaces is studied and

illustrated by good diagrams and pictured models. This is a help to the explanation of the methods of production of the many and diverse injuries to which the joint is subject. The lesions are taken one by one and dealt with as to frequency, pathogenesis, mechanics, diagnosis, progress, treatment, and prognosis.

There is a noticeable preference for operative methods with the use of staples, some of them with close, others very wide, prongs, all of them, of course, of fine calibre. He does not hesitate to use several such staples for multiple injuries of the condyles and shaft, fastening them in place with a wire loop. In the case of the Monteggia injury he figures treatment of the ulna with a long medullary pin introduced through the olecranon. Some forty-six pages are devoted to complicating nerve injuries and their treatment.

The book is well documented with a considerable bibliography and is well produced and copiously illustrated.

**Penicillin Therapy and Control in 21 Army Group**  
Published under the direction of the Director of Medical Services, 21 Army Group, with Introduction by the Consulting Surgeon 8½ x 5½ in Pp 365 May, 1945

This brochure of some three-hundred-odd pages contains a wealth of information that the average surgeon cannot readily obtain from any other source.

It contains sixty pithy articles dealing with every aspect of wounds due to modern warfare and the treatment of such wounds by penicillin.

Brigadier A. E. Porritt writes the introduction, and one can see his stimulating ideas throughout the book, as consulting surgeon to 21 Army Group he did much to make penicillin available to every wounded man.

It may be said that every aspect of war surgery and medicine, including venereal disease, was treated with penicillin, and the results give the surgeon and physician a very good account of its real value.

## BOOK NOTICES

*[The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest to our readers.]*

**Anæsthesia in Operations for Goitre** By STANLEY ROWBOTHAM, M.D., D.A., Honorary Anaesthetist to the Royal Free Hospital, to Charing Cross Hospital, and to the Royal Cancer Hospital 8½ x 5½ in Pp 104 + viii, with 54 illustrations 1945 Oxford Blackwell Scientific Publications Ltd 12s 6d net

**The Early Diagnosis of the Acute Abdomen** By ZACHARY COPE, B.A., M.D., M.S. (Lond.), F.R.C.S. (Eng.), Surgeon to St Mary's Hospital, etc. Ninth edition 8½ x 5½ in Pp 262 + xv, with 38 illustrations 1946 London Geoffrey Cumberlege, Oxford University Press 12s 6d net

**Modern Anæsthetic Practice** *The Practitioner Handbooks* Edited by the late Sir HUMPHREY ROLLESTON, Bt, G.C.V.O., K.C.B., M.D., F.R.C.P., and ALAN MONCRIEFF, M.D., F.R.C.P. Second edition 8½ x 5½ in Pp 150 + viii, with 7 illustrations 1946 Eyre & Spottiswoode (Publishers) Ltd, for *The Practitioner* 12s 6d net

**Hospital Care of the Surgical Patient** By GEORGE CRILE, jun., M.D., Surgeon, Cleveland Clinic, and FRANKLIN L. SHIVELY, jun., M.D., Assistant Surgeon, Cleveland Clinic. With a Foreword by EVARTS A. GRAHAM. Second edition 8½ x 5½ in Pp 288 and 18, with 25 illustrations 1946 Springfield, Ill. C. C. Thomas (London Baillière, Tindal & Cox) 14s net

**Fractures of the Jaws** By ROBERT H. IVY, M.D., D.D.S., F.A.C.S., Professor of Plastic Surgery, School of Medicine, University of Pennsylvania, etc., and LAWRENCE CURTIS, A.B., M.D., D.D.S., F.A.C.S., Associate Professor of Plastic Surgery, School of Medicine, University of Pennsylvania. Third edition, thoroughly revised 9 x 5½ in Pp 174, with 220 illustrations 1946 London Henry Kimpton 22s 6d net

**Choc traumatique** Étude clinique, physio-pathologique et thérapeutique. By J. CREYSSSEL, Professeur Agrégé à la Faculté de Lyon, and P. SUIRE, Ex-Chef de Clinique Chirurgicale à la Faculté de Paris. With a Preface by Professor R. LERICHE 10 x 6½ in Pp 310 1944 Paris Masson et Cie Fr 160

**The 1945 Year Book of Industrial and Orthopedic Surgery** Edited by CHARLES F. PAINTER, M.D., Orthopedic Surgeon to the Massachusetts Women's Hospital and Beth Israel Hospital, Boston 7 x 4½ in Pp 432, with 225 illustrations 1946 Chicago The Year Book Publishers Inc (London H. K. Lewis & Co Ltd) 18s net

**Anatomical Atlas of Orthopedic Operations** By L. S. MICHAELIS, M.D., Orthopedic Surgeon, E.M.S., Member of the Orthopedic Unit, Botleys Park War Hospital 9½ x 7½ in Pp 67, with 73 illustrations in colour 1946 London William Heinemann (Medical Books) Ltd 25s net

**A Manual of Surgical Anatomy** By TOM JONES and W. C. SHEPARD. Pocket edition 7½ x 5½ in Pp 254 + vi, with 267 illustrations, 153 in colour 1945 Philadelphia and London W. B. Saunders Co 15s net

**A Pocket Surgery** By PHILIP H. MITCHNER, C.B., C.B.E., T.D., M.D., M.S. (Lond.), F.R.C.S. (Eng.), D.Ch. Hon. (Durham), D.L., Honorary Surgeon to H.M. The King, Surgeon and Lecturer in Surgery, St Thomas's Hospital, etc., and A. HEDLEY WHYTE, D.S.O., T.D., M.B., M.S. (Durham), F.R.C.S. (Eng. and Edin.), Honorary Surgeon, Royal Victoria Infirmary, Newcastle-on-Tyne, etc. Second edition 7½ x 4½ in Pp 272 + viii 1946 London J. & A. Churchill Ltd 8s 6d net

**Hypoglycémies spontanées. Le Traitement chirurgical de l'Hyperinsulinisme** By P. MAILLET-GUY, Professeur Agrégé à la Faculté de Médecine de Lyon, and P. MAILLET, Professeur à la Faculté de Médecine de Lyon. With a Preface by Professor H. MONDOR 7½ x 5½ in Pp 102, with 17 illustrations 1944 Paris Masson et Cie Fr 55

**Sciatiques et Lombalgies par Hernie postérieure des Disques intervertébraux** By D. PETIT-DUTAILLIS, Professeur de Pathologie chirurgicale à la Faculté de Médecine, Chirurgien de l'Hôpital Bichat, and S. DE SÈZE, Médecin des Hôpitaux de Paris 9½ x 6½ in Pp 180, with 133 illustrations 1945 Paris Masson et Cie Fr 235

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